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## Editorial

### ALCHEMY AND HOPE

IN the early centuries of the Christian era certain Greeks in Alexandria began experiments with metals in the hope that they could transform them from the baser ones to precious material. With avarice as their stimulus, they devoted their lives to this work. By apprentice training and by the written word their experiences, their technics and their results were passed on to succeeding generations. With unflinching hope of ultimate success, men expended their lives in this process, hoping to find the Philosophers' Stone, whose power would be so great that it could accomplish their purpose of conferring certain desired quantities to elements so as to change their physical characteristics.

The work of the alchemists was not easy. Often it was carried out in the face of derision of the populace. At other times, it is true, it was carried out under the protectorship and even the subsidy of the reigning monarch. Some, as the kings of Bohemia, placed the alchemists workshops in the compounds of their palaces, and encouraged their efforts. They did not put their faith in the miraculous or supernatural; they ascribed their efforts to an imitation of nature.

It is interesting to note that they worked with, or attempted to achieve, slight differences from natural elements; for example,

they needed sulfur that was not quite sulfur, but some principle which was derived from it—the philosophers' elixir or stone.

Now, after almost twenty centuries of effort, the goal has been attained. The transmutation of elements is now a reality. The philosophers' stone has been found. The terminology is a bit changed; the transmutation of the elements is now called a chain reaction. The philosophers' stone is now called an atomic pile, and the sulfur which is not quite sulfur is called an isotope. Hope, added to the undying efforts of man, sponsored by individuals, by monarchs, by states and then by an Allied High Command and two billion dollars has resulted in the fulfillment of the dream of those Alexandrian Greeks in the first centuries of our era.

In the sixteenth century, Paracelsus diverted alchemy to the field of medicine. He believed that the purpose of the alchemist should be for the benefit of the ill rather than the manufacture of gold. Today we need another Paracelsus who would divert the products of their dreams to the benefit of man rather than to their destruction. But we also need more of the alchemists' hope, hope that the many barren wastes of our knowledge of the cause and cure of disease will be penetrated by the



processes of research. We must eschew the derision of the dreamers who propose the fantastic. We must aid their adventures into the field of science. We must enlist the aid of monarchs and states, seek their sponsorship, so that we, who now battle somewhat picayunishly against the ravages of cancer, heart disease and so many human ills, will not have to hope for an answer for centuries. Let us turn our hope into active effort.

Let us not make the mistake of housing our modern alchemists in hovels. Let us

make our scientists into the most respected members of the community. Let us lure the ambitious into the fields of research. The alchemist sought to find a way of making gold, but, life is far more precious than gold. Nevertheless, let us pave the way with more of the precious metal, so that the road of the scientist shall not altogether be a drab and difficult one. And let us, more than anything else, inoculate him with the hope of the alchemist.

CARL BECK, M.D.



THE cause of metastasis is not known. There are many factors involved, such as the richness of the blood and lymph supply, the frequency of freeing cells into the vessels, pressure of the tumor, fibrosis and encapsulation, size of the growth, and injury of the tissues.

From "Metastases Medical and Surgical" by Malford W. Thewlis (Charlotte Medical Press).

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# Original Articles

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## THE LYNCH OPERATION FOR CARCINOMA OF THE RECTOSIGMOID

JEROME M. LYNCH, M.D. AND G. JOHNSON HAMILTON, M.D.  
NEW YORK, NEW YORK

THIS technic was first employed in 1935. It is designed for those cases in which the tumor is too low to permit removal by anterior resection and anastomosis. It showed so much promise that a preliminary report was published in the *American Journal of Surgery* in June, 1937. At that time it was stated that shock was so much diminished as to increase the operability rate greatly. The hope was expressed that this benefit was achieved without any decrease in the salvage rate. It was emphasized that only time could prove whether or not this was so. The answer to this question is now presented in an analysis and follow-up of the first fifty cases submitted to this technic.

During the period under consideration sixty-five patients were seen with carcinoma at or about the rectosigmoid junction. Eleven of these refused operation or went to other surgeons. Four were considered inoperable because of carcinomatosis. Fifty were operated on by the Lynch technic. This series was composed of twenty-nine males and twenty-one females. Broder's method of classification revealed two grade one, forty-seven grade two and one grade three. Analysis by Duke's method revealed one grade A, twenty-one grade B and twenty-eight grade C.

### OPERATIVE TECHNIC

Since there have been many small but helpful changes in the technic as first published, it will be described in full. The operation is usually performed under low spinal anesthesia, but the responsibility

for the choice of anesthesia is always delegated to the anesthetist. The patient is placed in the exaggerated Trendelenburg position with the buttocks protruding beyond the edge of the table and with a sandbag under the sacrum. This permits easy access to the sacrococcygeal joint. The area is cleaned with 10 per cent tannic acid in alcohol. In the male, a large silk woven or gum elastic catheter is introduced into the bladder and fastened *in situ*. A purse-string suture of heavy silk is placed about the anus. Incisions are made from the tuber-ischii to the sacrococcygeal joint.

The coccyx is excised, preserving the few attachments of the levator ani to the sacrum. These attachments and the rectum are freed from the hollow of the sacrum by blunt dissection. The resulting cavity is filled with a hot pack.

The incisions at the tuber-ischii are continued anteriorly to meet in the perineum at the base of the scrotum or just behind the vagina. These incisions are deepened until the plane of cleavage between prostate and rectum or vagina and rectum is defined. These structures are then separated by blunt dissection.

The packing is removed from the hollow of the sacrum. The levators and lateral ligaments of the rectum are defined and divided between the clamps as laterally as possible. The rectum is now free and the peritoneal reflection is visible and may be incised. In a few cases, the specimen to be removed is short enough so that the peritoneum need not be opened but merely stripped off the sigmoid much as a banana

is peeled. Once the peritoneal cavity has been opened a loop of sigmoid will prolapse. Crushing clamps are applied at the optimum point above the tumor. The inferior mesenteric artery or its branches are ligated in such a manner as to preserve the

rather soft rubber tube 2 cm. in diameter is inserted into the bowel and secured with a suture. The wound is inspected to ensure hemostasis. The peritoneum is not closed unless there is prolapse of the small bowel in which event the prolapse is controlled

TABLE I  
OPERATIVE DEATHS

Case No.	Age	Sex	Cm. from Anal Verge	Classification		Cm. of Specimen	Cause of Death
				Broder	Duke		
5904	40	F	10	3	C	34	Ascending infection of urinary tract; mors tenth postoperative day
7219	41	M	8	2	C	41	Paralytic ileus; mors sixth postoperative day
5428	57	M	3	2	C	18	Paralytic ileus; hiccoughs for 11 days; mors thirteenth postoperative day
6026	66	M	10	2	C	35	Ascending infection of urinary tract; hypostatic pneumonia; mors twenty-fifth postoperative day
7085	70	F	5	2	C	25	Surgical shock; mors twenty-five hours postoperatively

TABLE II  
RECURRENCES

Case No.	Age	Sex	Cm. from Anal Verge	Classification		Cm. of Specimen	Recurrence Discovered	Site of Recurrence	Died
				Broder	Duke				
6028	27	M	7	2	C	22	6 mo.	local	10 mo.
6069	38	F	15	2	C	41	11 mo.	local	Reoperated
7042	42	M	11	2	C	48	11 mo.	local	12 mo.
5605	42	M	7	2	C	18	6 yr.	spine	6½ yr.
7006B	45	M	8	2	C	31	2 mo.	local	4 mo.
5842	49	M	5	1	B	40	8 yr.	liver	8 yr. 1 mo.
5848	51	F	5	2	C	50	2 mo.	general	6 mo.
6061	53	M	5 and 8 (double)	2	C	28	19 mo.	local	Reoperated
5676	53	M	1	1	C	30	in-operable	local	Reoperated
5759	58	F	2	2	B	15	2 yr.	local	Reoperated
5516	63	F	2	2	C	22	18 mo.	local	21 mo.
7019	63	M	2	2	C	35	1 yr.	local	18 mo.
5585	65	F	10	2	B	21	3 yr.	local	3 yr. 6 mo.
7048	67	F	5 and 10 (double)	2	C	28	5 mo.	local	8 mo.
7205	69	F	10	2	B	26	16 mo.	local	24 mo.
5829	69	M	7	2	B	21	14 mo.	general	16 mo.

blood supply to the point of severance of the sigmoid. The bowel is then divided between crushing clamps with the actual cautery. The crushing clamp is removed. A

with a few interrupted sutures. The wound is packed with gauze soaked in 10 per cent tannic acid in alcohol. This packing is kept moist with the same solution and

removed in forty-eight hours together with the flatus tube. From that time on, the wound is sprayed several times a day with this solution contained in an atomizer. The bowels are moved by means of magnesium sulfate given at the time that the study of 500 of our patients operated upon by the combined methods revealed that 70 per cent of the recurrences were local. This technic is no exception. Despite the removal of almost all the soft tissue in the pelvis, all but three of the recurrences were

TABLE III  
NON-ATTRIBUTABLE DEATHS

Case No.	Age	Sex	Cm. from Anal Verge	Classification		Cm. of Specimen	Comments
				Broder	Duke		
7038	50	F	5 and 8 (double)	2	C	70	Pneumonia 6 years postoperatively
6061	53	M	5 and 8 (double)	2	C	28	Pulmonary tuberculosis; 4 years postoperatively
6060	66	M	5	2	B	28	Suicide two years postoperatively to provide insurance for wife
5647	68	F	1 and 8 (double)	2	B	12	Pneumonia 2 years postoperatively
5892	73	M	5	2	B	15	Suicide 4 years postoperatively; senile dementia
7006A	80	M	4	2	B	20	Pneumonia 2 months postoperatively

flatus tube and packing are removed. No other digressions are made from the present established methods of pre- and post-operative care.

ANALYSIS OF CASES

There were five operative deaths in this series. Familiarity with the technic, improved team work within the institutions, and the great advances in pre- and post-operative care should greatly decrease this operative mortality. Even if this were not so, it is believed that the high operability rate would justify a somewhat higher operative mortality. (Table I.) It is believed that the first four of these cases could probably have been saved if the present methods of pre- and postoperative care had been available.

RECURRENCES

It is the rule for local recurrences to predominate in all types of operation for cancer at or about the rectosigmoid. A

local. One dreads to think of the fate in store for those subjected to the "muscle-saving" operations. (Table II.) It is to be noted that two of these were double lesions and seven of them were within 5 cm. of the anal verge. Four of them were deemed suitable for reoperation and are described more fully.

*Reoperations.* Case No. 6069 (Table II) underwent a hysterectomy seven months after the excision of her rectosigmoid. At this time no evidence of carcinoma was discovered. Nevertheless, four months later a local recurrence was found and the patient was reoperated upon. She succumbed twenty months later to a generalized carcinomatosis. Case No. 6061 (Table II) was discovered to have a local recurrence nineteen months after resection of the rectosigmoid. A second operation was performed, but the patient died four years later of pulmonary tuberculosis which existed prior to the first operation. A complete autopsy showed no evidence of carcinoma. Case No. 5676 (Table II) was found to have involvement of the prostate

and urethra. On three different occasions he developed a perforation of the urethra which was repaired by sliding grafts of carcinomatous tissue. He died of carcinomatosis four years after the first operation. In the interim he carried on his profession but succumbed to carcinomatosis one year later. (Table III.)

## FATE UNKNOWN

It is to be regretted that in this, as in every series a certain number of patients

TABLE IV  
FATE UNKNOWN

Case No.	Age	Sex	Cm. from Anal Verge	Classification		Cm. of Specimen	Known to Be Alive and Well
				Broder	Duke		
7193	48	F	12	2	B	45	2 yr. and 8 mo. postoperatively
5998	55	M	10	2	C	39	9 mo. postoperatively
7023	60	F	8	1	A	42	3 yr. and 9 mo. postoperatively
6022	66	M	5	2	C	31	3 yr. and 6 mo. postoperatively
7160	69	F	7	2	B	38	1 yr. postoperatively
5614	70	M	2	2	B	20	2 yr. and 6 mo. postoperatively
7101	71	M	3	2	B	25	2 yr. and 1 mo. postoperatively

TABLE V  
SALVAGED

Case No.	Age	Sex	Cm. from Anal Verge	Classification		Cm. of Specimen	Alive and Well
				Broder	Duke		
6015	31	F	7	2	C	25	6 yr. 1 mo.
5605	42	M	7	2	C	18	Died 6 yr. 6 mo.
6032	48	F	14	2	C	51	8 yr.
5876	43	M	8	2	C	35	9 yr.
5895	49	M	10	2	B	33	7 yr. 10 mo.
5842	49	M	5	1	B	40	Died 7 yr. 11 mo.
7038	50	F	5 and 10 (double)	2	C	70	Died 6 yr.
5612	52	M	7	2	B	30	10 yr. 5 mo.
7213	52	M	8	2	C	28	6 yr. 2 mo.
clinic	57	M	3	2	C	18	7 yr. 1 mo.
7060	58	F	9	2	B	40	7 yr. 5 mo.
5963	59	M	8	2	B	18	8 yr. 5 mo.
6068A	60	M	8	2	B	25	7 yr. 9 mo.
7295	61	M	7	2	C	30	6 yr. 1 mo.
5883	62	M	5	2	B	25	9 yr. 11 mo.
5539	65	F	5	2	C	21	10 yr. 10 mo.
5519	65	F	2	2	B	20	11 yr. 5 mo.
5732	72	F	7	2	B	23	9 yr. 9 mo.

as a lawyer except for the above mentioned three periods of hospitalization. Case No. 5759 (Table II) was discovered to have a local recurrence two years after resection of the rectosigmoid. She was reoperated upon

disappeared from our ken. That this group is so large, is due to frequent moves of patients and doctors, as well as to the disruption of routine inherent in the war years. (Table IV.)

## SALVAGED

Under this category, only those patients are included who were alive and well at least five years postoperatively. (Table v.)

## SUMMARY

An attempt has been made to analyze the first fifty cases submitted to the Lynch technic and to follow up those patients to the present time. All relevant facts have been included, and the reader has been permitted to compile his own statistics.

The series was composed of twenty-nine males and twenty-one females; classified according to Broder's system, there were

two grade one, forty-seven grade two and one grade three. According to Duke's system, there were one grade A, twenty-one grade B and twenty-eight grade C.

The operative technic has been described.

The pre- and postoperative care has been omitted except where this technic calls for departure from the normal.

## CONCLUSIONS

It is believed that this technic greatly increased the operability rate without unduly increasing the operative mortality, and it is shown that the salvage rate is very high despite the high proportion of older patients and poor operative risks.



THE most frequent benign growth in the sigmoid or the rectum is the solitary adenoma. The squamous papillo-fibroma (squamous polyp) resulting from hypertrophy of an anal papilla is also quite common. All other benign neoplasms are of infrequent occurrence in this region.

From "Ambulatory Proctology" by Alfred J. Cantor (Paul B. Hoeber, Inc.).

# CARCINOMA OF THE THYROID GLAND IN CHILDREN\*

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CARCINOMA of the thyroid gland is a relatively rare tumor. Schreiner and Murphy give an incidence of 0.37 per cent of 11,212 malignancies recorded at the New York State Institute for the Study of Malignant Diseases.<sup>1</sup> Operations for malignancies of the thyroid occupied 1.03 per cent of thyroidectomies performed at the Mayo Clinic between 1907 and 1928.<sup>2</sup> At the Lahey Clinic the incidence of primary malignancies of the thyroid was 1.7 per cent, and six of 258 cases occurred in patients under fourteen years of age—an incidence of 2.3 per cent—although two of these were in aberrant thyroid tissue.<sup>3</sup> It has been generally accepted that the general incidence of carcinoma of the thyroid in children is less than 1 per cent of the total incidence of the disease; however, the ratio of malignant to non-malignant diseases of the thyroid is about the same in children as in adults.<sup>4</sup>

Pathologically, epithelial tumors of the thyroid in children tend to follow the same cellular pattern as in adults and are most commonly found in a solitary adenoma of the gland. Warren's classification to these tumors is one of the most workable and one of the most generally accepted. It is as follows:

- Group I (1) Fetal adenoma with blood vessel invasion
- (2) Papillary adenocystoma with blood vessel invasion
- Group II Adenocarcinoma
  - (1) Papillary
  - (2) Alveolar
- Group III (1) Diffuse small cell carcinoma
- (2) Small compact cell carcinoma
- (3) Giant cell carcinoma
- (4) Fibrosarcoma

Most of the tumors in Group I and II are

those that develop in a solitary adenoma; they represent the slower growing tumors. In Group I the diagnosis of malignancy rests on finding blood vessel invasion. In Group II there is invasion of the tissues surrounding the adenoma, the papillary type being the more benign—these tumors usually spread via the lymphatics but these are the group that metastasize to bone. Group III are the most highly malignant and are the type that is frequently found in aberrant thyroid tissue. They are the hardest to diagnose early in the disease.

A very useful clinical classification includes those which develop within a thyroid nodule and those which are diffuse in one or more lobes of the gland; the first type being the most benign, the easiest to suspect and cure. Three of the following four cases fall into this group.

Reports in the literature are not frequent. Hughes<sup>5</sup> reported a case of a thirteen year old girl with metastatic glands who was well three months after operation. Schultz<sup>6</sup> records a case in a girl five and one-half years old. Moncrieff and Poynton<sup>7</sup> record the autopsy findings in a girl aged eleven. Pemberton and Dixon<sup>2</sup> present two cases under nine years of age and eight more under nineteen (but it may be that sarcomas were also included in this group). Hare<sup>3</sup> reports six cases, three of which had previously been reported by Cattell;<sup>8</sup> two of these cases were in aberrant thyroid tissue and one was in a thyroglossal duct cyst. Kennedy<sup>4</sup> reports eight cases from the Mayo Clinic ranging between seven and fourteen years of age seen between 1909 and 1934. Only two of his cases were in a previously existing adenoma. Other reports by Lee,<sup>9</sup> Berard,<sup>10</sup> Meleney<sup>11</sup> and Taylor and Wilkinson<sup>12</sup> all concern patients under twenty years of age.

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The following case reports are of interest because they represent a fairly large series in this disease and all four were seen in Charity Hospital within a period of only two years. They are also interesting because carcinoma of the thyroid in adults is much less frequently seen here than in the North despite the high incidence of adenomatous goiter seen at this hospital. The ages range between six years (seventy-two months) and eleven years.

#### CASE REPORTS

**CASE I.** A. F., a healthy eight and one-half year old girl, entered Charity Hospital September 28, 1942, for removal of a lump in the neck, noted and growing steadily since the age of three. In the past two years it grew more rapidly and attempts at treatment had been made. For most of this time she was treated with various medicines, some containing iodine. For three months she had been getting larger doses of iodine which did not affect the growth of the lump. For two days before admission she had a maculopapular rash scattered over body but not the extremities, with itching and excoriated skin. Physical examination was negative except for the skin and neck. Her blood pressure was 110/60, pulse 90, respirations 25, temperature 98.6°F. The neck showed a slightly tender non-fluctuant mass about 5 by 4 by 3 cm. lying underneath and not attached to the right sternomastoid nor to the tissues of the neck. It moved with swallowing and seemed to be separate from the thyroid. Peripheral blood count, blood chemistry and urine analysis were essentially normal. Vocal chords were normal.

She was taken to surgery on October 12th. An adenomatous mass was found well separated from the remaining thyroid tissue by its capsule and attached to the medial portion of the right lobe of the thyroid. It was completely removed. The pathological report stated that the mass was 6 by 4 by 3.4 cm. and weighed 40 Gm. Diagnosis: Malignant adenoma of the thyroid with undifferentiated cells and invasion of the blood vessels. Her postoperative course was uneventful. A roentgenogram of her chest January 28, 1943, showed no evidence of metastasis. She has remained free of symptoms to the present time according to the social worker's report.

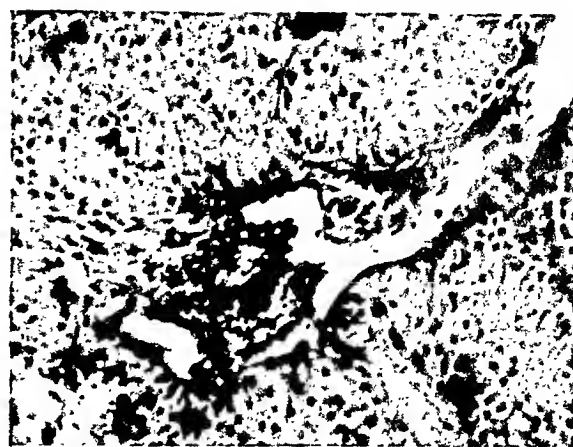


FIG. 1. Case I. Shows numerous large undifferentiated tumor cells, especially at the lower margin and tumor invasion of the blood vessel in the center of the field. High power  $\times 600$ .

**CASE II.** G. M., an eleven year old white female, was admitted to Charity Hospital on January 27, 1943, with the diagnosis of hypothyroidism. It was noted in October, 1941, at a clinic examination that the child was obviously mentally and physically retarded. A history obtained at that time showed that she had always been retarded and did not walk or talk until after two years of age. Her basal metabolic rate at that time showed a minus 36 per cent with all other signs of hypothyroidism. She was started on thyroid and was built up to 3 gr. daily. Her condition improved and she became more alert and more energetic but in August, 1942, a nodular enlargement of her thyroid was noted and Lugol's solution was given. In October, 1942, she was again placed on thyroid gr.  $\frac{1}{2}$  three times a day. She showed little improvement and the nodule remained. Psychiatric examination showed a mentally retarded child.

She was admitted to the pediatric ward at which time her work-up pointed to hypothyroidism. A biopsy of the thyroid nodule was advised by surgery. This was done on February 23rd at which time the entire right lobe was removed. This was reported as papillary adenocystoma of low grade malignancy. Her condition was satisfactory and on the basis of the pathological report a total thyroidectomy was advised and performed on March 9th. The right lobe had been completely removed at the previous operation. All of the remaining thyroid tissue was removed at this time. The pathologist found a 2 mm. nodule on this side with blood vessel invasion,



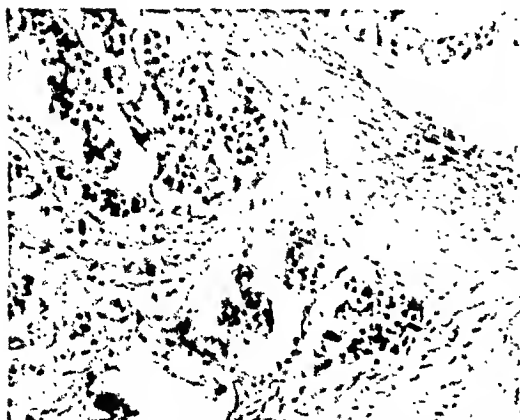


FIG. 2. Case 11. Shows undifferentiated tumor cells in the dense fibrous stroma of the otherwise atrophic gland.  $\times 200$ .

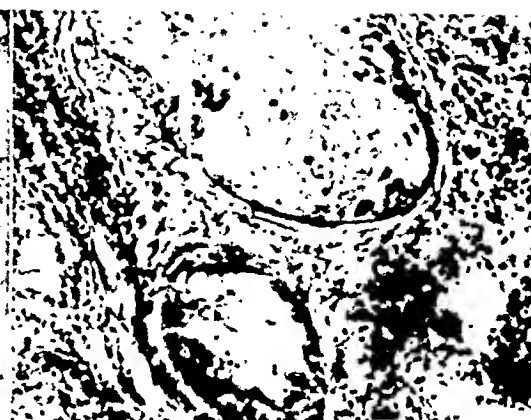


FIG. 3. Case 11. Marked hypoplasia of the thyroid acini present. Some tumor cells can be seen at the bottom of this section.  $\times 200$ .

presenting the same microscopic picture as found on the right side. Her postoperative course was good. She was given 3 gr. thyroid daily and later cut down to 1. She was readmitted on November 16, 1943, to see how well stabilized she was. A complete laboratory work-up showed normal basal metabolism rate and all other laboratory tests were within normal limits. The November 19, 1943, chest plate was negative. Her mental status has not improved but she has no evidence of recurrence of metastases at the present time.

**CASE III.** J. M., a ten year old white female, was admitted to Charity Hospital on January 27, 1943, with her sister for observation of a mass in the neck. The swelling developed slowly and was of about fifteen months' duration. The child was a mild cretin type, smaller than a girl her age should be. There was a palpable nodule in the right lobe of her thyroid. She was started on thyroid extract by her local physician but this was discontinued in favor of Lugol's solution on October 8, 1942. October 30, 1942, thyroid gr.  $\frac{1}{4}$  three times a day was again started. The gland became smaller but the nodule persisted. She walked at eighteen months and talked at two and one-half years of age. The basal metabolic rate on October 7, 1942, was  $-17$  per cent. Repeated on February 4, 1943, it was  $-8$  per cent. The blood chemistry work-up was essentially normal. Bone x-rays on November 12, 1942, revealed epiphyseal development of a child five years of age. On February 1, 1943, carpal x-rays showed normal development. Skull plates were normal. Psychiatric examination showed normal mental development. Venous pressure was 83.0.

She was physically retarded but had always gotten along all right in school. Biopsy of the nodule on March 16, 1943, showed slight fibrosis with a typical epithelial hyperplasia which microscopically was practically identical with that seen in her sister's thyroid. She was taken to surgery on March 16, 1943, and a total thyroidectomy was performed. The report was—"Multiple nodules of fetal adenoma. This tumor although not definitely invasive in the sections studied should probably be considered malignant. The remaining gland shows slight atrophy and atypical hyperplasia of the epithelium. Cellular structure very similar to that seen in the patient's sister." She was put on gr. 1 thyroid daily and the postoperative course was uneventful. She was readmitted May 10, 1943, August 9, 1943 and November 14, 1943. Her condition was good, the mental development excellent and all blood chemistry studies were normal. Basal metabolic rate normal with the patient on gr. 1 thyroid daily. No evidence of recurrence at the present time.

**CASE IV.** J. B., a five year eleven month old boy, first entered Charity Hospital May 26, 1941, at the age of two with a complaint of hoarseness; he could never speak above a whisper. He had a cold at the age of four months but no inflammation of the upper respiratory tract since. He now was having increasing difficulties with breathing and after crying he would almost stop breathing. The physical examination was essentially normal. A laryngoscope was used on June 6, 1941, and multiple polyps of the larynx were seen. On June 9, 1941, a tracheotomy was performed and on June 16, 1941, the polyps were removed



FIG. 4. Case III. Shows tumor nodule in center joining with the hypoplastic thyroid tissue. On the extreme right hand side of this section blood vessel invasion can be seen.  $\times 200$ .

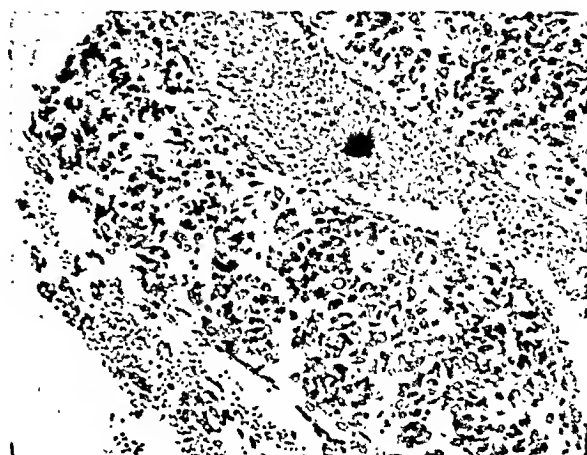


FIG. 5. Case IV. Diffuse carcinomatous involvement of the entire gland. Shows numerous tumor cells in the blood vessel at the lower left.  $\times 200$ .

with a snare and the bases cauterized with silver. The pathological diagnosis was squamous papilloma with no evidence of malignancy or a specific etiological agent. The laryngoscope was again used on July 7, 1941, and there was no evidence of any polyps although a note was made that very little of the vocal chords were left. He was discharged on July 11, 1941, and followed in the Ear, Nose and Throat Clinic. The laryngoscopic results on August 25, 1941, were normal.

He was again readmitted to the Ear, Nose and Throat wards on August 5, 1944, with a complaint of difficulty in breathing as well as hoarseness. The respiratory difficulty had been increasing in the last six months. Physical examination showed a small occipital abscess and an enlargement of all the lymph nodes in the posterior half of the neck. He could not speak above a whisper. There were several nodules palpable on each side of the trachea which were interpreted as lymph nodes. The thyroid was not enlarged. The remainder of the physical examination was normal. His respiratory difficulties became worse and on August 7, 1944, another low tracheotomy was performed. A small lymph node removed at this time was sent to the pathology department. The patient became much better and on August 21, 1944, he was laryngoscoped and several small papillomas were removed. These were also reported as benign. The lymph node which was removed at the time of the tracheotomy was reported as a metastatic carcinoma of the thyroid gland to a lymph node and he was transferred to surgery. On September 8, 1944, under endotracheal anesthesia a total thyroidectomy was

performed. All regional lymph nodes were removed also at this time. Only one parathyroid was adherent to the tumor and this was removed. There was some difficulty removing the gland from the trachea to which it was very adherent. The entire left lobe and a small part of the right lobe were infiltrated by the tumor. Several small lymph nodes were found near the gland and were also removed. The pathological report was adenocarcinoma of the thyroid with metastases to the parathyroid gland and then to the adjacent lymph nodes. His postoperative course was excellent except for temporary hypothyroidism which cleared up when his dosage of thyroid was increased to 5 gr. daily. The tracheotomy was discontinued on September 13, 1944, and on September 25, 1944, deep ray therapy was begun. He was given a 4,598 R. total skin dose through each of two portals over a period of thirty-five days. There has been no evidence of a recurrence at the present time. He is still on 5 gr. thyroid daily with no ill effects from this much drug. There is no evidence of recurrence or metastases at the present time.

#### COMMENTS

Case I is interesting from the point that the patient is apparently free of disease three years later after undergoing only a simple excision of the adenoma which had been present most of her life. This stresses the point that the only difference between a benign and a malignant adenoma of the thyroid is the finding of the vascular inva-

sion in the microscopic examination of the tissue.

Cases II and III have several interesting features; in the first place the tumors occurred in sisters; secondly they were practically identical microscopically and thirdly both girls had definite evidence of hypothyroidism, the older of the two unfortunately was allowed to become a cretin before medical aid was sought. It is especially interesting to note that in Case II a small (not palpable) nodule from the opposite lobe also showed malignancy and if the policy of simple excision of the presenting nodule were followed cancerous tissue would have been left in the gland. All three of the above patients were treated by surgery alone and none have yet shown any evidence of recurrence; despite this the author believes that the second and third patients should have had deep x-ray therapy postoperatively as children stand x-ray therapy very well, and over a long series of patients more cures will be obtained by giving postoperative irradiation. (X-ray therapy was not thought to be indicated by our x-ray department at that time.)

Case IV illustrates the difficulty of making a clinical diagnosis on the diffuse type of malignancy. Because of his laryngeal pathological condition this child was very carefully followed in the hospital and clinics since the age of two, and at no time did physical examination of the thyroid region give any hint of a pathological disorder in the gland; the diagnosis was made only by microscopic examination of a metastatic node which was grossly normal. His response to surgery and x-ray were excellent and despite the metastases to the local nodes and parathyroid gland there is no evidence of recurrence at the present time.

#### DIAGNOSIS

The diagnosis of these tumors is completely a pathological one and it is only when the disease is hopelessly beyond cure that we can be certain of a clinical diagnosis of carcinoma of the thyroid. These four

cases illustrate that if treated promptly these patients have an excellent outlook. It is only by removing all solitary nodules of the thyroid and subjecting them to careful pathological study that early diagnosis of malignancy can be made and cures can be secured, regardless of the age of the patient or the duration of the disease.<sup>13</sup> The difficulty of making an early diagnosis in the diffuse type of growth is obvious as they present no symptoms and physical examination of the gland is normal—as was seen in our Case IV, the diagnosis was made quite by accident and even by that time local metastases were present. In Taylor and Wilkinson's patient all attention was paid to the pulmonary symptoms which were thought to be inflammatory and it was only at autopsy that the real pathological condition was discovered.

#### TREATMENT

The treatment of these patients depends upon the pathological disturbance present. If, as was seen in Case I, there is a well encapsulated nodule which is easily separated from the rest of the gland and the rest of the gland is normal, simple excision of the nodule with a small margin of normal thyroid tissue should result in a cure. If any of the local lymph nodes are involved these should also be removed and intensive postoperative irradiation should be given. In the patient who presents a deep-seated nodule which is not well encapsulated even though it can be readily separated, a frozen section should be made on the removed lobe and if the nodule is malignant a total thyroidectomy should be performed; this should be followed by intensive postoperative irradiation. There is considerable difference of opinion on the above statement and many men would only remove the presenting nodule; however, as was seen in Case II there may be another small malignant focus somewhere else in the gland that is not apparent at the time of operation. Frequently, a positive diagnosis cannot be made by frozen section and unless the diagnosis is certain paraffin

sections should be obtained before the entire thyroid is removed; this procedure was followed in Cases II and III. In Kennedy's<sup>4</sup> series the author believes that the indication for total thyroidectomy is definitely shown, as two of his eight patients had local recurrences after subtotal removal of glands of low grade malignancy, and there is reason to believe that a third subject in the eight cases would prove to have a recurrence if a biopsy of the nodules in his neck were performed. Since thyroid extract is easily available and low in price the author sees no reason for risking recurrences by being conservative in the removal of these growths. Both Cases III and IV of the present series are showing full normal development on oral thyroid extract.

In a diffuse growth, without metastases distant to the neck, a total thyroidectomy with removal of all local lymph nodes and any other tissue that is involved by the tumor (i.e., parathyroid as was present in Case IV) should be done and this should be followed by intensive postoperative irradiation as soon as skin sutures are removed. Some authors believe in doing a radical neck dissection in these cases, however, with improved radiological technics this is probably not necessary. If, however, the lymph nodes of the neck are grossly involved by the tumor and there is no evidence of distant metastases, a radical neck dissection will probably give the higher percentage of cures. However, our radical attacks to this disease are still so new that it is not definitely known whether radical surgery will result in more cures than a simple removal of the gland followed by intensive postoperative x-ray therapy by the newer technics. The author believes that in the obvious presence of multiple metastases to the lymph nodes of the neck a radical neck dissection combined with deep ray therapy will result in more cures than depending on x-ray alone to sterilize the involved glands. In patients

with distant metastases the procedure depends primarily upon the condition of the patient. In a patient in good condition the author believes that removal of the gland followed by postoperative irradiation will result in prolongation of life as well as comfort and certainly will prevent later obstructive symptoms from occurring. In poor risk patients with widespread disease, of course, palliation is all that can be done.

#### SUMMARY

Four cases of carcinoma of the thyroid in children between the ages of six and eleven are presented followed by a discussion of the diagnosis and treatment. Photomicrographs of the tumors are shown.

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# INGUINAL HERNIA

## AN ANALYSIS OF 2,643 OPERATIONS

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ONE of the problems most frequently encountered by the general surgeon, now as in years past, is that of how to treat a patient with an inguinal hernia so that he may be allowed an early return to a gainful occupation with the least possible chance of recurrence. The challenge to the surgeon's judgment, ingenuity and skill is no less great today than it was a century ago, though remarkable progress has been made in recent years toward arriving at a better understanding of the anatomy of the inguinal region and the measures necessary for the cure of hernia. Differences in anatomical concepts, operative technics, suture materials and preoperative and postoperative care have been credited with the varying successes or failures of surgeons throughout the years. Older and more experienced men are wont to emphasize the personal equation in accounting for the differences in statistical results in contrasted series of cases. The more inexperienced among us are inclined to seize and hasten to apply any new development that may be introduced in the field of reparative surgery in an attempt to eliminate whatever fault is believed to be responsible for previous failures. The last word has not as yet been said in regard to the cause of failure in hernia repair for recurrence is still common. However, the general consensus is that recurrence, with few exceptions is the result of error on the part of the surgeon in selecting the proper type of operative procedure to be employed in the repair of a particular type of hernia or in his application of surgical principles in effecting the repair. Much has been said both for and against the various standard hernia operations with the variations and modifications of each including the use of many kinds of suture materials. But, in our opinion, the operative procedure and suture material to be employed should be adapted

to the type of hernia to be repaired rather than *vice versa*.

No attempt will be made here to trace the stages in the development of the various operations presently used in the treatment of hernia. The types of hernias encountered in this series are described and classified and the various operations used in their repair are explained in detail. The criteria for the use of each operation are enumerated. The 2,643 hernia repair operations upon 2,040 patients summarized in Tables I to V represent the total number of hernias repaired in the U. S. Veterans Administration Hospital in Dayton Ohio, in the years 1934 to 1944 inclusive. The patients were all male veterans, twenty-two to seventy-nine years of age. Sixty-five per cent of these men were admitted for operation during the fifth decade of their lives. The average age for the group is 47.3 years. Fifty-five per cent of the hernias were on the right side, with 45 per cent on the left side. Thirty per cent of the patients had bilateral inguinal hernias. Eighty-four per cent of the total number of cases have been followed from one to ten years. In the course of follow-up, 61 per cent were examined on one or more occasions by a physician, usually one of our staff. Twenty-three per cent of our follow-up reports were received in reply to routine questionnaires which are sent out from the hospital every twelve months to those patients who have not returned for examination within a year after discharge. On 423 or 16 per cent of the cases in the series we have no follow-up records. Almost all of these latter patients were operated on in the years 1939 to 1944, a period of tremendous population migration and all attempts to contact them have been unsuccessful to date. Perhaps more of them will report back to us in later years and further follow-up studies may be possible. Eighty-four per

cent of all patients were followed one to five years; 16 per cent were followed six to ten years.

Recurrence rates in all classes of hernias and all types of operations range from 0 per cent in the Cooper's ligament-fascial suture repair of primary hernias (forty-four cases) to 50 per cent in the McArthur fascial suture repair of recurrent indirect hernias (two cases). The overall recurrences total 177 cases or 6.7 per cent of the series. Wound complications at the time of operation or subsequently (Table v) include the inadvertent opening of the bladder during dissection of the sac, orchidectomy, temporary swelling of the homolateral testicle without subsequent atrophy, testicular atrophy, wound hematoma and wound infections in which there was purulent drainage with or without sloughing of the sutures. The pulmonary complications following operation consisted of atelectasis, two cases; bronchopneumonia, one case; and embolism (fatal), one case.

The inadvertent opening of the bladder, occurring in six cases in this series, is not an uncommon accident in hernia repair operations and in our experience has not been a serious complication. The bladder in each instance was opened during the dissection of the bladder from a direct sac or from the direct locule of a bilocular sac. In five of these patients healing was prompt and convalescence uneventful. The sixth developed an abscess in the prevesical space which required incision and drainage. Prompt closure of the bladder opening by means of interrupted sutures of fine catgut and an indwelling urethral catheter left in place continuously for fourteen days postoperatively are usually the only measures needed to prevent seepage of urine into the wound with resultant urinary fistula.

The low incidence of pulmonary complications we attribute to preoperative and postoperative management. No elective hernia operation is performed until the patient is free of symptoms of upper respiratory infection. Following surgery patients

are encouraged to wave their arms about, talk, cough, breathe deeply and move their lower extremities. They are allowed out of bed to void on the day of operation and are encouraged to be up and out of bed for increasing periods of time daily from the first postoperative day. On the second or third postoperative day they walk to the toilet and to the solarium without assistance. Dressings are changed and alternate skin sutures are removed on the fifth day. The remaining sutures are removed and the last dressing applied on the seventh day. A shower bath is permitted on the eighth day and patients are discharged on the tenth to twelfth day following surgery.

Three deaths occurred as a result of or associated with operation. Autopsy revealed massive pulmonary embolism in one case and adynamic ileus in another. Permission for autopsy was refused in the third case and the cause of death was not determined.

The 2,643 hernias are classified as primary and recurrent and further subdivided into indirect, direct, bilocular, sliding, diverticular, adiposus and femoral. The indirect hernias are those in which the mural defect lies at the internal inguinal ring, the sac making its exit medial and adjacent to the spermatic cord, lateral to the inferior epigastric vessels and extending for a variable distance along the cord. Direct hernias are those in which the mural weakness or defect lies in the triangle (Hesselbach's) medial to the inferior epigastric vessels, above the inguinal (Poupart's) ligament, and lateral to the rectus muscle. Bilocular hernias have both a direct and an indirect component. This type of hernia is known also as the direct-indirect, saddlebag or pantaloons hernia. In sliding hernias the sac consists in whole or in part of an abdominal viscus usually the cecum and ascending colon or bladder on the right and the descending colon and sigmoid colon or bladder on the left.<sup>4</sup> Diverticular hernias are those in which herniation occurs through a defect in the transversalis fascia in the floor of the inguinal canal. Diverticu-



lar hernia sacs may or may not communicate with the peritoneal cavity. They may occur alone or in combination with other types of hernia. The fatty diverticulum is a rare variety of diverticular hernia consisting of a spherical, smooth, encapsulated, solitary, fatty mass protruding through a defect in the floor of the inguinal canal occasionally seen in obese patients who have attenuated or degenerated transversalis fascia.<sup>3</sup> Hernia adiposus results from the hypertrophy and downward progression of the finger-like extension of preperitoneal fat which normally is seen adhering to the lateral aspect of the subaponeurotic portion of the spermatic cord.

Femoral hernias occur as a result of mural defects between the inguinal and iliopectineal ligaments and are almost invariably associated with indirect, direct, or bilocular inguinal hernias. For this reason they are classified as one type of inguinal hernia and the supraligamentous or inguinal approach is described and recommended in their treatment. The femoral sac or the femoral locule of an inguinofemoral sac may protrude from the abdominal cavity anterior to the external iliac vein and artery as a prevascular locule. It may pierce the lacunar (Gimbernat's) ligament adjacent and lateral to the pubic tubercle, the so-called translacunar locule. It may make its exit through the femoral canal which is bounded anteriorly by the inguinal (Poupart's) ligament, posteriorly by the iliopectineal (Cooper's) ligament, medially by the lacunar (Gimbernat's) ligament and laterally by the external iliac vein, a so-called pectineal locule. The femoral sac may consist of any two or all three of these locules. The femoral or infraligamentous incision provides access only to the femoral canal and that portion of the sac within and distal to it. Consequently with this incision exploration of the inguinal region is not possible unless the incision is extended upward through the inguinal ligament and inguinal hernia locules may be overlooked at operation. With the inguinal or supraligamentous incision exploration of both

inguinal and femoral regions is possible and additional saecular or mural components of the hernia may be readily recognized and corrected without sacrificing the integrity of the inguinal ligament itself.

Herniorrhaphy and hernioplasty are the names given to the two classes of operative procedures employed in the repair of the hernias in this series.

#### HERNIORRHAPHY

Herniorrhaphy is the repair of hernia by means of the rearrangement of mural structures usually with funicular displacement without using fascial sutures or grafts and without muscle transplants. This operation has been chosen to close defects in the transversalis fascia and internal oblique muscle at or near the internal inguinal ring when the muscular and fascial structures seen at operation were considered sufficiently strong to prevent recurrence of the hernia following their approximation to the inguinal ligament or to Cooper's ligament by means of interrupted catgut or silk sutures.

In the routine herniorrhaphy performed at this hospital under spinal block or local anesthesia a 5 inch (12.5 cm.) incision is made through the skin and superficial fascia approximately 1 inch (2.5 cm.) above and parallel to the inguinal ligament. Vessels are isolated and clamped prior to division and then are tied with No. 000 catgut ligatures. The fibers of the external oblique aponeurosis are separated from the external inguinal ring upward and laterally for a distance of approximately 3 inches (7.5 cm.) or to a point slightly above and lateral to the internal inguinal ring, making a medial and a lateral aponeurotic flap. These flaps are then reflected medially and laterally, respectively. The spermatic cord is then elevated from its bed, divested of adherent areolar tissues and retracted laterally on a soft cotton or rubber tissue tape. The external spermatic veins frequently found on the posterior aspect of the cord are divided between hemostats and

ligated with No. 000 catgut ligatures at this stage. Upon careful examination of the medial aspect of the cord in any type of hernia, the sac can be found lying closely adherent to the medial side of the vas deferens in the region of the internal ring. The sac is then opened and explored digitally. Regardless of the type of hernia present the sac will be most easily dissected, delivered into the wound and ligated if pulled out through the internal ring lateral to the inferior epigastric vessels. This procedure obviates the opening of the transversalis fascia and prevents further damage to an already weakened wall. With small hemostats applied to the cut margin of the sac two fingers are inserted inside the sac and exploration is carried out to determine the true nature of the hernia.

It is almost impossible to classify an inguinal hernia accurately prior to exploration and so it is unwise to decide upon the exact type of repair to be carried out until all of the features of the sac and mural structures have been assessed under direct visualization and palpation. The exploration will reveal whether the sac is predominantly direct, indirect, or bilocular, whether or not there are associated diverticula, either communicating or not communicating with the peritoneal cavity and whether or not there is a femoral locule in addition to the inguinal locule or locules. After the completion of exploration traction is made on the margins of the sac and all surrounding structures are carefully dissected away up to the true neck of the sac. This point can be readily recognized by the narrowing just before the sac opens into the main peritoneal cavity. Dissection is not stopped when the bladder is encountered. In this series the bladder was dissected from the sac in direct or bilocular hernias for a distance of from 1 to 2 inches (2.5 to 5 cm.) in a total of 1,2-8 or 49 per cent of cases.

The sac is next twisted through a complete turn of 360 degrees and a purse-string suture of No. 0 black silk is placed twice about its extreme upper portion,

above the neck if possible, tied, and the redundant portion of the sac amputated, whereupon, the ligated sac stump retracts out of sight behind the internal oblique muscle. Transfixion of this stump is not necessary if the purse-string suture is

TABLE I  
HERNIORRHAPHY IN PRIMARY INGUINAL HERNIA

Classification of Hernias	Recurrences	Poupart's Ligament		Cooper's Ligament
		Catgut Sutures	Silk Sutures	Silk Sutures
Indirect	Cases	123	327	1
	Recurrences	9	23	0
	% Recurrence	7.3	7	0
Direct	Cases	11	92	12
	Recurrences	4	7	0
	% Recurrence	36	7.5	0
Bilocular	Cases	132	878	22
	Recurrences	14	56	0
	% Recurrence	10.6	6.3	0
Sliding	Cases	8	48	2
	Recurrences	1	8	0
	% Recurrence	12.5	17	0
Femoral	Cases	.....	12	21
	Recurrences	.....	1	2
	% Recurrence	.....	8.3	9.5
Adiposus	Cases	.....	5	
	Recurrences	.....	1	
	% Recurrence	..	20	
Diverticular	Cases	.....	8	1
	Recurrences	.....	1	0
	% Recurrence	.....	12.5	0
Total	Cases	274	1370	50
	Recurrences	28	97	2
	% Recurrence	10	7	3.4

properly placed and snugly tied. High dissection, ligation and excision of the sac are essential in good hernia surgery. The ligated sac is the first line of defense against a recurrent hernia.

The fibers of the internal oblique muscle are now retracted medially and the transversalis fascia identified and cleared of



adherent muscle fibers and loose, areolar tissue. Diverticula in the floor of the inguinal canal are excised or inverted and the fascial defects are closed by means of purse-string sutures of No. 0 black silk prior to reconstruction of the abdominal

TABLE II  
HERNIORRHAPHY IN RECURRENT HERNIA

Classification of Hernias	Recurrences	Poupart's Ligament		Cooper's Ligament
		Catgut Sutures	Silk Sutures	Silk Sutures
Recurrent indirect	Cases	7	15	1
	Recurrences	0	3	0
	% Recurrence	0	20	0
Recurrent direct	Cases	16	40	7
	Recurrences	2	2	1
	% Recurrence	12.5	5	14.3
Recurrent bilocular	Cases	1	22	5
	Recurrences	0	4	0
	% Recurrence	0	18	0
Recurrent femoral	Cases	....	12	6
	Recurrences	....	1	2
	% Recurrence	....	8.3	33.3
Totals	Cases	24	89	19
	Recurrences	2	10	3
	% Recurrence	8.3	11.2	15.7

the pubic tubercle to the internal inguinal ring.<sup>1</sup> A second row of interrupted sutures of the same material approximates the lateral flap of the external oblique aponeurosis to the transversalis fascia medial to the inguinal ligament. The medial flap of the aponeurosis is then imbricated over the lateral flap behind the spermatic cord and sutured to the inguinal ligament again using the interrupted sutures. The defect in the aponeurosis above and lateral to the exit of the cord created by the original separation of the medial and lateral flaps is then closed with one or two interrupted sutures of the silk or catgut. These latter sutures must not be placed tightly enough to constrict the cord and yet they must close the opening snugly so as not to leave an orifice large enough to permit recurrent herniation about the cord.

An opening large enough to accommodate the cord and the surgeon's fingertip is considered adequate to allow for post-operative edema in the cord without impairing its circulation. As can be seen, the spermatic cord is transposed extra-aponeurotically by the imbrication of the flaps. The skin and superficial fascia are approximated in one layer with interrupted on-end mattress sutures of a fine dermal suture material.

Primary and recurrent hernias (1,757 in all) were repaired by this procedure with silk and catgut sutures. There were 136 recurrences in this group, an average of 7.7 per cent; 1,370 primary hernias were repaired with silk with ninety-seven or 7 per cent recurrences. (Table 1.) The eighty-nine recurrent hernias repaired by means of herniorrhaphy with silk sutures resulted in ten or 11.2 per cent recurrences. (Table 11.) In 298 of the herniorrhaphies performed with catgut sutures, thirty or 10.1 per cent recurrences developed. Of these, 274 were primary hernias in which twenty-eight, or 10 per cent of cases, developed recurrence subsequently. (Table 1.) Twenty-four recurrent hernias repaired with catgut by routine herniorrhaphy developed two or 8 per cent recurrences. (Table 11.)

wall. If the mural defect is small, fascial structures are strong and there is no associated direct or femoral hernia, herniorrhaphy may be selected as the repair of choice. In this event slight tension is made on the lateral flap of the external oblique aponeurosis and all adherent bits of loose areolar tissue are wiped away from the flap and the inguinal ligament with a gauze sponge moistened in warm normal saline solution.

The transversalis fascia is then approximated without tension to the shelving portion of the inguinal ligament with interrupted sutures of No. 000 black silk or No. 0 twenty-day chronic catgut in a line of sutures 5 to 8 mm. apart extending from

Complications following catgut herniorrhaphy consist of testicular atrophy in one patient. (Table v.) There were no wound infections or hematomas. Complications in the silk herniorrhaphy series were twenty-six wound infections, three wound hematomas, nineteen cases of testicular swelling without subsequent atrophy, eleven additional cases in which atrophy followed postoperative testicular swelling, four orchidectomies performed at time of operation and five cases in which the bladder was inadvertently opened during the dissection of the sac.

The incidence of recurrence and wound complications noted in this group of herniorrhaphies is in keeping with the results reported in recent years from other hospitals in various parts of the United States. Judging from these figures, silk sutures appear to offer the patient a better chance for cure of his hernia than do catgut sutures, provided herniorrhaphy is the indicated procedure and the same meticulous dissection and repair are carried out in all cases.

#### HERNIOPLASTY

Hernioplasty, the hernia repair in which fascial sutures or grafts or muscle grafts are transplanted to the hernia region to replace or strengthen relaxed or attenuated structures, was used in those cases in which such additional support was considered necessary at operation. However, in the past five years the indications for the use of fascial sutures and transplants have been recognized more and more often by our staff with a concomitant reduction in the recurrence rate of various types of hernia.

In the event the patient is found to have a direct hernia or if the mural defect is large, the abdominal wall is relaxed, if large diverticula are present in the floor of the inguinal canal, a femoral locule is present; if the patient has had a previous operative repair of a hernia with subsequent recurrence for any reason or if the muscular and fascial structures of the wall are absent or attenuated, a hernioplasty is

the operation of choice. Very large mural defects are best repaired by means of pedicled fascia grafts according to Wangenstein's<sup>5</sup> method. General laxity of the abdominal wall, the presence of a femoral locule, absence or attenuation of the

TABLE III  
HERNIOPLASTY IN PRIMARY HERNIA

Classification of Hernias	Recurrences	Poupart's Ligament		Cooper's and Poupart's Ligament	Cooper's Ligament
		Gallie Fascial Suture	McArthur Fascial Suture	Pedicled Fascia Grafts	
Indirect	Cases	76	15	1	3
	Recurrences	2	2	0	0
	% Recurrence	2.6	13.3	0	0
Direct	Cases	122	30	1	12
	Recurrences	4	3	0	0
	% Recurrence	3.2	10	0	0
Bilocular	Cases	100	94	2	11
	Recurrences	1	—	0	0
	% Recurrence	.5	7.4	0	0
Sliding	Cases	52	11	2	6
	Recurrences	0	0	0	0
	% Recurrence	0	0	0	0
Femoral	Cases	1	....	..	11
	Recurrences	0	....	..	0
	% Recurrence	0	....	..	0
Adiposus	Cases	8	3		
	Recurrences	0	0		
	% Recurrence	0	0		
Diverticular	Cases	11	3	..	1
	Recurrences	0	0	..	0
	% Recurrence	0	0	..	0
Total	Cases	460	156	6	44
	Recurrences	7	12	0	0
	% Recurrence	1.5	7.6	0	0

inguinal ligament or coexisting multiple locules are considered indications for the Cooper's ligament type of hernioplasty.<sup>5</sup> Four types of hernioplasty, the Gallie,<sup>6</sup> the McArthur,<sup>7</sup> the Wangenstein pedicle fascia graft and Cooper's ligament repair were employed in a total of 808 or 30 per cent of the cases in this series.

The Gallie hernioplasty consists of high ligation and excision of the sac, approximation of the transversalis fascia to the

shelving portion of the inguinal ligament, imbrication of the medial and lateral flaps of the external oblique aponeurosis with extra-aponeurotic transposition of the spermatic cord using one or two sutures of fascia obtained from the iliotibial tract

TABLE IV  
HERNIOPLASTY IN RECURRENT HERNIA

Classification of Hernias	Recurrences	Poupart's Ligament		Poupart's and Cooper's Ligament	Cooper's Ligament
		Gallie Fascial Suture	McArthur Fascial Suture	Pedicle Fascia Grafts	Cooper's Ligament Fascial Suture
Recurrent indirect	Cases	17	2	1	2
	Recurrences	1	1	0	1
	% Recurrence	6	50	0	50
Recurrent direct	Cases	42	..	11	9
	Recurrences	3	..	0	0
	% Recurrence	7	..	0	0
Recurrent bilocular	Cases	35	..	4	4
	Recurrences	3	..	1	1
	% Recurrence	8.5	..	25	25
Recurrent sliding	Cases	....	..	1	
	Recurrences	....	..	0	
	% Recurrence	....	..	0	
Recurrent femoral	Cases	1	..	10	2
	Recurrences	0	..	4	1
	% Recurrence	0	..	40	50
Recurrent diverticular	Cases	....	..	1	
	Recurrences	....	..	1	
	% Recurrence	....	..	100	
Totals	Cases	95	2	28	17
	Recurrences	7	1	6	3
	% Recurrence	7.3	50	21.8	17.6

of the fascia lata. This hernioplasty differs from the herniorrhaphy previously described only in that continuous running sutures of fascia are used in the fascia to ligament approximation in place of the interrupted silk or catgut sutures used in the herniorrhaphy.

The fascial sutures are removed through a transverse incision 3 cm. long on the lateral aspect of the thigh one hand's breadth distal to the greater trochanter of the femur. Through this small incision one or more sutures 3 or 4 mm. wide and

averaging 20 to 25 cm. in length may be readily removed with a Masson fascia stripper. The process of extracting the suture is facilitated by internally rotating and immobilizing the donor extremity prior to making the incision. This can be done by slipping a small, snugly fitting half sandal over the forepart of the foot and attaching this sandal to the opposite side of the operating table by a connecting strap.<sup>2</sup> As soon as the fascial suture has been removed from the thigh, it is fixed at one end to a large-eyed curved steel needle by means of No. 000 black silk ties. Sutures and attached needles are then placed in a gauze sponge previously moistened with normal saline solution at room temperature to be kept until the actual time of suturing. It is important that the sponge not be hot, else the suture will be partially cooked, will swell, lose its elasticity and tensile strength and will slough out of the wound two to four weeks later. Sloughing will also occur if the suture is allowed to dry out before use.

Removal of the fascial suture from the thigh results in little additional postoperative pain for the patient. The discomfort subsides as rapidly as that in the inguinal wound and not one of our patients has complained of postoperative weakness in the donor thigh.

The Gallie hernioplasty was chosen in the treatment of 555 patients of whom 460 had primary hernias (Table III) and ninety-five had recurrent hernias. (Table IV.) The recurrences following the repair of primary hernias varied from 0 per cent in the sliding, femoral and diverticular hernias to 3.2 per cent in the direct hernias with an overall recurrence rate of 1.5 per cent. The recurrent hernias repaired by the Gallie technic varied from 0 per cent recurrence in one femoral hernia to 8.5 per cent in the bilocular group with an overall recurrence rate of 7.3 per cent. The Gallie operation is not ordinarily considered suitable for femoral hernias; however, this operation was chosen by one of our surgeons in the treatment of one patient with a

primary femoral hernia and another with a recurrent femoral hernia with satisfactory results in both so far. The complications following the Gallie operation (Table v) consist of wound infections in seven cases, wound hematoma in one case, testicular

to its tendinous insertion into the pubic tubercle. The lower end of the suture is not freed from its bony attachment. A large eyed, curved steel needle is affixed to the free end of the suture by means of a No. 000 black silk tie and this suture is used to

TABLE V  
WOUND COMPLICATIONS

	Poupart's Ligament Herniorrhaphy		Cooper's Ligament Hernior- rhaphy Silk Sutures		Gallie Hernio- plasty Fascial Suture		McArthur Hernio- plasty Fascial Suture		Hernio- plasty Pedieled Fascia Graft		Cooper's Ligament Hernio- plasty Fascial Suture	
	Catgut Suture	Silk Sutures										
Number of operations . . .	298		1459		78		555		158		34	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Wound infections . . . . .	0	0	26	1.7	2	2.5	7	1.2	2	1.2	1	3
Wound hematomas . . . . .	0	0	3	.2	0	0	1	.18	0	0	0	0
Swollen testicle without atrophy . . . . .	0	0	19	1.3	0	0	3	.5	0	0	1	3
Testicular atrophy . . . . .	1	.3	11	.6	0	0	6	1	0	0	1	3
Orchidectomy at opera- tion . . . . .	0	0	4	.3	0	0	1	.18	0	0	1	3
Bladder opened . . . . .	0	0	5	.3	0	0	0	0	1	.6	0	0

swelling in three cases, testicular atrophy in six cases and orchidectomy in one case. There were no deaths in this group and the bladder was not opened during dissection.

The McArthur hernioplasty is similar to the Gallie hernioplasty in that a fascial suture is used to approximate the transversalis fascia to the inguinal ligament and the medial and lateral flaps of the external oblique aponeurosis are imbricated superficial to the transversalis fascia allowing extra-aponeurotic transposition of the spermatic cord. The difference in the two operations lies in the difference in the origin of the fascial sutures. The suture in the McArthur hernioplasty is derived from the edge of the medial flap of the external oblique aponeurosis. A suture 2 or 3 mm. wide is split from the aponeurosis beginning at its lateral extremity at the point of insertion of the muscle fibers down

approximate the transversalis fascia to the inguinal ligament. The fascial suture is not long enough to allow completion of the imbrication of aponeurotic flaps after the original fascia to ligament closure so that it becomes necessary to suture the lateral flap to the transversalis fascia and the medial flap to the inguinal ligament with interrupted sutures of No. 00 black silk.

There were 158 patients who received the McArthur hernioplasty. One hundred fifty-six of them had primary hernias (Table III) and two had recurrent hernias. (Table IV.) There were no recurrences in the primary sliding and diverticular hernias. Recurrences in the bilocular hernia, direct hernias and indirect hernias were 7.4, 10 and 13.3 per cent, respectively, with a total recurrence rate of 7.6 per cent. Of the two recurrent indirect hernias repaired by the McArthur technic one recurred a second

time leaving a recurrence rate of 50 per cent. The recurrence rate for the 158 cases is 8.2 per cent, a figure slightly higher than that in the silk herniorrhaphy series (Tables 1 and 11) and considerably higher than the recurrence rate in the Gallie fascial suture group.

Complications resulting from the McArthur hernioplasty (Table v) were two wound infections, and one case in which the bladder was inadvertently opened during the dissection. There were no instances of wound hematomas, swollen testicles, testicular atrophy, or orchidectomy following this operation.

In thirty-four patients large hernias secondary to major defects in the fascial components of the abdominal wall were repaired with pedicled grafts from the iliotibial tract of the fascia lata from the homolateral thigh. In this operation the sac is dissected, ligated and excised in the usual manner; the inguinal ligament, transversalis fascia and Cooper's ligament are identified and freed of adherent structures. Then a vertical incision 20 cm. long is made along the lateral aspect of the thigh beginning a hand's breadth below the greater trochanter of the femur. The skin and superficial fascia are retracted on either side of the wound and a pedicled graft 4 to 5 cm. wide attached at its upper end to the tensor fascia lata muscle containing the entire iliotibial tract of the fascia lata is freed from the underlying muscle. Its free distal end is turned upward and passed beneath the skin and superficial fascia of the thigh through the femoral canal into the inguinal region in the manner described by Burton and Ramos.<sup>5</sup> The graft is then fanned out to cover the defect in the transversalis fascia. The free edges of the graft are sutured to the transversalis fascia or rectus sheath above and medially and to the inguinal ligament and Cooper's ligament laterally and below by means of interrupted sutures of No. 00 black silk. The medial and lateral flaps of the external oblique aponeurosis are imbricated using interrupted sutures of No. 00 black silk

further strengthening the graft and transposing the spermatic cord outside the aponeurosis. The skin and superficial fascia of both wounds are approximated with interrupted on-end mattress sutures of No. 000 dermal. Hemostasis and strict asepsis are especially important in this operation because of the extent of the dissection and the danger of contamination in the transfer of the graft from the thigh through the femoral canal into the inguinal region.

Recurrences in this series varied from 0 per cent in the indirect, direct, bilocular, sliding, recurrent indirect, recurrent direct and recurrent sliding hernias to 25 per cent in the recurrent bilocular hernias, 40 per cent in the recurrent femoral hernias and 100 per cent in the one recurrent diverticular hernia. Complications consist of one wound infection, one case of testicular swelling without subsequent atrophy, one testicular atrophy, and one orchidectomy performed at the time of operation. There were no postoperative wound hematomas and the bladder was not entered during the sac dissection.

Cooper's ligament operation is indicated in the treatment of all femoral hernias including combined inguinofemoral hernias. Other indications for this type of repair are inguinal hernias associated with attenuation or absence of the inguinal ligament and those hernias accompanied by marked laxity of the abdominal wall.

Cooper's ligament is a tough fibrous band which extends laterally from the lacunar ligament lying closely adherent to the pectineal line of the superior pubic ramus. This ligament offers a superb anchorage for the fascial strata of the abdominal wall from the lacunar ligament laterally to the external iliac vein. It is readily accessible and is available when exclusion of the femoral canal is desired or when the inguinal ligament is inadequate for inguinal reconstruction. In this series Cooper's ligament has been utilized in a total of 139 cases. In seventy-eight or 57 per cent of these patients the herniorrhaphy type of

operation was done. In this procedure the transversalis fascia is sutured to Cooper's ligament with interrupted No. 6 black silk sutures after the sac has been dissected, ligated and excised. The aponeurotic flaps are then imbricated and the spermatic cord transposed extra-aponeurotically. In sixty-one patients receiving hernioplasty, the fascia to ligament approximation was completed with the aid of a continuous fascial suture running from the pubic tubercle to the external iliac vein and then the space between the inguinal ligament and Cooper's ligament was obliterated through the use of a second fascial suture which pulled the inguinal ligament down to close proximity with the superior pubic ramus.

There were five recurrences (6.4 per cent of cases) in the seventy-eight patients receiving Cooper's ligament herniorrhaphy with silk sutures. Wound infection followed operation in two instances. There were no other complications in this group.

There were three recurrences (4.8 per cent of cases) in the sixty-one patients receiving Cooper's ligament hernioplasty with fascial sutures. Infection developed in two of these wounds and additional complications consisted of testicular atrophy in one patient and orchidectomy in one other.

#### CONCLUSIONS

A study of 2,040 patients in the U. S. Veterans Administration Hospital in Dayton, Ohio, operated upon for 2,369 primary and 274 recurrent inguinal hernias over a period of eleven years indicates a trend recently toward the use of fascial sutures and fascial grafts in hernia repair operations. A concomitant drop in the recurrence rates of many types of hernia apparently justifies this trend. Hernioplastic procedures are generally more difficult to perform and are more time consuming than are herniorrhaphies, but the incidence of cure is so much higher in the former that the

additional time required appears to be well spent. In our experience there are no more wound infections or other complications following the use of fascia lata sutures and grafts than are encountered when silk sutures are used.

The McArthur fascial suture hernioplasty has been almost entirely eliminated from our armamentarium as a result of our studies of recurrence rates in the various methods of repairing hernias. We have found this operation somewhat less effective than herniorrhaphy with silk sutures and decidedly inferior to the Gallie fascial suture hernioplasty.

The Wangenstein pedicled fascia graft operation is reserved for those patients with large defects in the fascia of the abdominal wall which cannot be adequately closed by procedures requiring less extensive dissection.

Cooper's ligament offers a firm anchorage for the transversalis fascia and for the external oblique aponeurosis when exclusion of the femoral canal is necessary or when the inguinal ligament is absent or insufficiently strong to insure satisfactory inguinal reconstruction.

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# FRACTURE FIXATION BY TRANSARTICULAR PIN\*

## A TECHNIC FOR CONTROL OF SEVERE ANKLE FRACTURES

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**T**RIMALLEOLAR fracture of the ankle may be extremely disabling. A major cause of disability may be the difficulty in maintaining reduction. Open reduction and internal fixation of the displaced posterior fragment is often indicated; however, such a procedure is technically difficult and permanent limitation of motion with pain may still result after surgical intervention. Another alternative, skeletal fixation above and below the fracture incorporated in the cast has not been as successful as might be desired.

A removable partially intramedullary transarticular pin has been used successfully to maintain reduction in this difficult multiple fracture involving the joint.

In rationalizing such an approach the additional damage to the joint surface of a small pin perforation seemed negligible compared with the initial traumatic damage. The technic is simple. At the time of election, after surgical preparation of the extremity, a pin is applied through the calcaneus for application of traction by clevis. By traction and gentle manipulation, reduction of the fracture dislocation can usually be effected. A small gauge Steinman pin is then inserted with a motor drill from the medial aspect of the tibial cortex about 3 inches above the ankle joint. This pin is passed through the intramedullary canal of the tibia, across the joint,

through the talus and finally emerges lateral to the calcaneus in a silent area, thus maintaining inversion of the ankle. The point does not come through the skin. The heel traction pin is removed and a short leg plaster cast is applied incorporating the cork-tipped upper end of the transarticular pin. The cast and pin are removed in six weeks. At this time, in the presence of x-ray evidence of callus, gentle mobilizing exercises and underwater therapy are instituted. Weight bearing is allowed after mobilization when the clinical and x-ray appearance show adequate healing.

Two illustrated cases are presented. One, the common trimalleolar fracture with posterior displacement of the foot, and two, a trimalleolar fracture with a more uncommon anterior displacement of the foot. In both of these, initial attempts at plaster immobilization were unsatisfactory. This procedure was carried out, reduction was obtained by skeletal traction and fixation was positive by the transarticular pin and short cast.

### SUMMARY

Reduction can be well maintained in trimalleolar ankle fractures by use of the transarticular pin. It is probable that this technic will decrease the incidence of open reductions for such fracture dislocations and also decrease the permanent disability following such injury.

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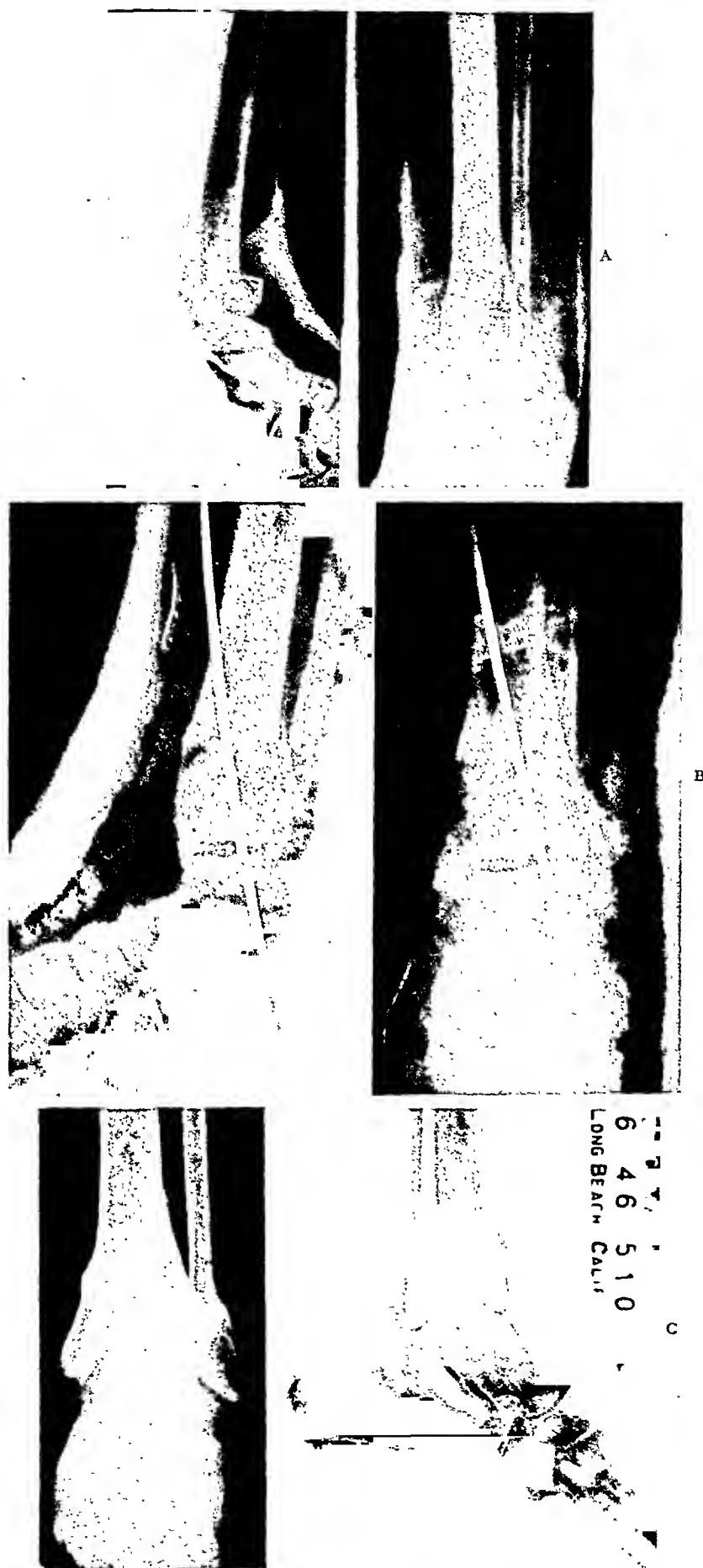


FIG. 1. Case 1. M. D., white female, sixty-two years of age. A, unsatisfactory closed reduction; B, after application of transarticular pin; C, end result; full motion, good function.



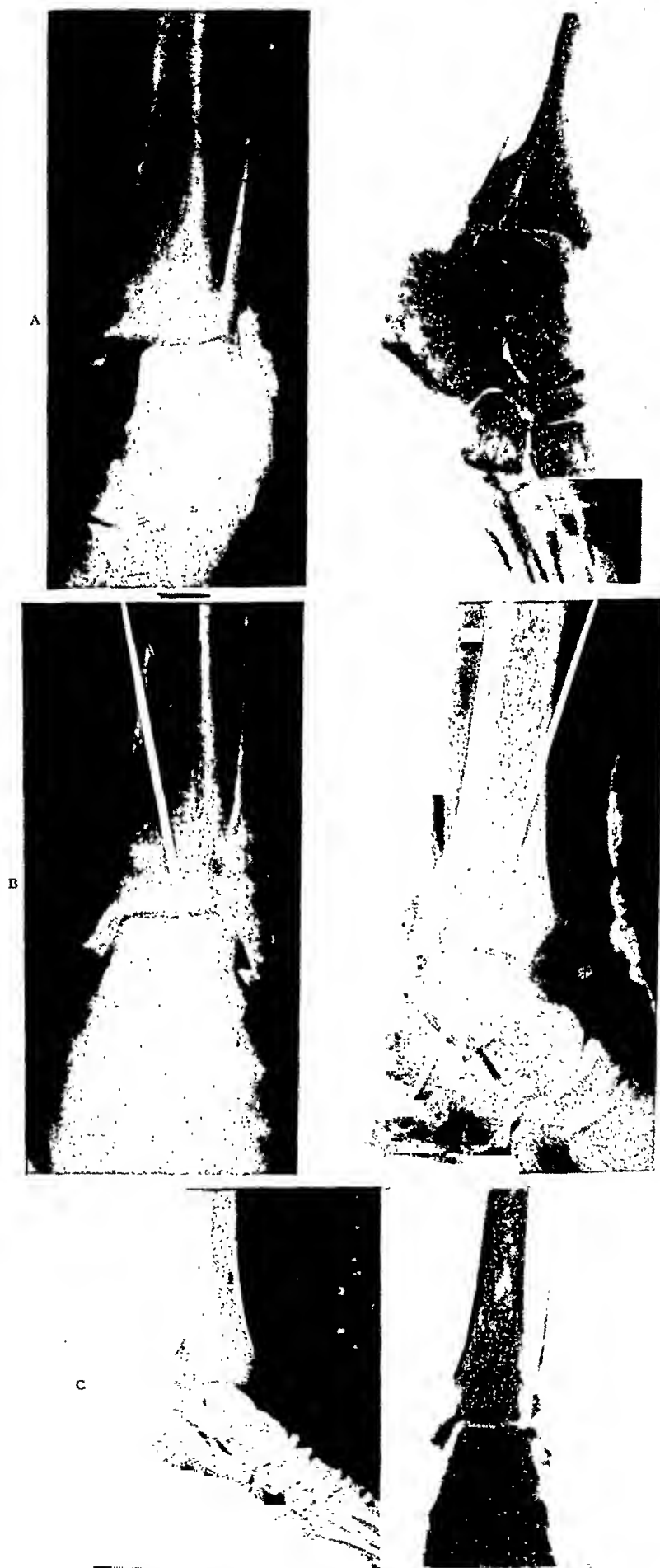


FIG. 2. Case 11. W. L., white male, thirty years of age. A, marked displacement of fragments; B, fixation by transarticular pin; C, appearance after removal of pin.

# CHOLECYSTITIS AND CHOLELITHIASIS IN THE YOUNG\*

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IT is a well known fact that cholecystitis and cholelithiasis occur primarily between the ages of thirty and fifty. The typical gallbladder patient has often been described by the old saying: fat, female, fair and forty. This picture was so well entrenched in the minds of most clinicians that for many years very little attention was paid to the problem of cholecystitis in the young. In fact, until the 1920's, this condition in a patient below the age of fifteen was considered a rare clinical entity warranting the publication of a case report.

Since that time, however, interest in this problem has been stimulated sharply by the comprehensive studies of Kellog, Beals and Potter. Kellog<sup>1</sup> reported sixty-four cases in 1923, and in 1928 Beals<sup>2</sup> was able to collect 124 cases. Prior to this time there is only one report of a fairly large group of collected cases to be found in the literature. This is in a paper published by Still<sup>3</sup> in 1899, describing twenty cases of biliary calculi in children and it represents one of the earliest attempts to explore the subject thoroughly. It was Potter,<sup>4</sup> however, who directed attention to this disease in patients under fifteen years of age by reporting a total of 226 collected cases in 1928. In the ten-year period from 1928 to 1938, Potter<sup>5</sup> discovered 206 additional patients, increasing his total of personal and collected cases to 432.

Recent authors undoubtedly influenced by these statistical studies no longer consider gallbladder disease an unimportant condition in children. In fact, it seems that there is a tendency by some clinicians to become too enthusiastic in their claims. Seidler and Brakeley<sup>6</sup> contend that the collected cases represent "but a merest fraction of the number of children afflicted."

It should be emphasized, however, that statistical data can be misleading unless a careful study is made of the types of cases presented. Twenty-six of the cases reported by Potter were congenital abnormalities of the biliary tract that occurred in the fetal or neonatal period. A good many other cases were also included which, strictly speaking, did not actually have primary gallbladder disease. Furthermore, in approximately 25 per cent of the cases, the diagnosis was based only on symptoms which are often misleading in children. It would appear, therefore, that the incidence of cholecystitis and cholelithiasis in the young is still infrequent but certainly not as rare as was formerly believed.

In order to study this problem from the clinical viewpoint, a survey was made of all the cases of cholecystitis in those patients under twenty-one seen at the Charity Hospital of Louisiana, New Orleans, from 1938 to 1935.

A total of twelve cases were reportable either on the basis of pathogenic findings or strong clinical evidence. There were ten additional cases that showed some clinical and laboratory evidence of gallbladder disease which may have been sufficient to warrant surgery if the patients had fallen into an older age group. Since these patients ranged from fifteen to twenty years of age, they were discharged on conservative management. No follow-up records were available to determine whether they have had persistent symptoms or subsequent operation. Because the evidence in these ten patients was not conclusive, their case reports were eliminated from this series. In addition, since this paper is devoted to the discussion of acquired gallbladder disease, primarily cholecystitis

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and cholelithiasis, no congenital lesions such as biliary atresias were considered.

Table I shows the age distribution of the patients whose case records are given below:

TABLE I	
Age Group	No. of Cases
0-5	0
6-10	1
11-15	0
16-20	11

The only male in the series was a seven year old boy in whom the diagnosis of chronic cholecystitis was made at operation. The remaining eleven patients were female, and their ages ranged from fifteen to twenty. Racial distribution played no significant rôle, six patients being white and six colored.

Six of the twelve patients were considered to have cholelithiasis. In four, the diagnosis was verified by actual demonstration of stones at operation. In the remaining two cases, no operation was performed but the diagnosis was made on the basis of typical attacks of biliary colic with evidence of mild jaundice. It is of interest to note that only one patient was shown to have stones on x-ray. In all the others, the x-ray revealed non-visualization of the gallbladder.

Table II shows the incidence of pregnancy in the eleven female patients presented in this review. Eight, or 73 per cent of the eleven females had been or actually were pregnant at the time of hospitalization. Five or 62 per cent of the eight patients were also found to have cholelithiasis. The only patient who had cholelithiasis without a history of preg-

TABLE II

Type of Case	Pregnant Cases	Non-pregnant Cases	Total
All cases.....	8	3	11
Surgically treated.....	5	3	8
Cases with stones.....	5	1	6

nancy developed typhoid fever during convalescence.

Table III indicates the basis for the diagnosis made in these patients.

TABLE III	
Diagnosis Made by	No. of Cases
Symptoms.....	2
Operation.....	9
Autopsy.....	1

## CASE REPORTS

CASE I. L. M. C., a colored female, aged twenty, was admitted to The Charity Hospital October 3, 1939, with the complaint of severe pain in the epigastrium and vomiting of two days' duration. At first the pain was cramping and colicky in nature but it soon became constant. In the previous three years the patient had suffered four or five such attacks, which were precipitated by the ingestion of greasy foods or sea food. There was a history of chronic constipation. The patient denied pregnancy but the presence of abdominal striae and pigmentation of the areolas of both breasts was considered as possible evidence of a previous pregnancy. Physical examination revealed an obese patient with a temperature of 99°F., and a blood pressure of 120/70; the abdomen showed marked tenderness in the right upper quadrant; the red blood cells were 3.8 million; white blood cells, 7,500 and the urine was negative for bile. The Kolmer and Kline tests were positive; cholecystogram failed to visualize the gallbladder. Cholecystectomy was performed four days after admission. The pathological report revealed the presence of subacute and chronic cholecystitis and cholelithiasis. The patient developed a pneumonitis postoperatively but made an uneventful recovery permitting her discharge on October 17, 1939. Four months later she returned to the clinic suffering from an incisional hernia and diabetes; however, her gallbladder symptoms had disappeared.

CASE II. L. S., a nineteen year old white female, was admitted April 25, 1938, with sharp, colicky pains in the right upper quadrant of the abdomen. She had experienced six or seven similar attacks during the previous six weeks, each being precipitated by the ingestion of greasy foods. There was a history of two previous pregnancies, with one living child as the result. Physical examination revealed an obese white female with a temperature of

98.6°F.; blood pressure 150/100 and a tenderness in the upper right quadrant of the abdomen. The laboratory data revealed the red blood cells, 5.3 million; white blood cells, 8,000; 87 per cent polymorphonuclears and an icterus index of 16. No bile was present in the urine. A cholecystogram failed to visualize the gallbladder. After one week in the hospital, the patient was discharged on medical management with a clinical diagnosis of cholecystitis and cholelithiasis.

CASE III. E. C. A., a nineteen year old white female, was admitted January 14, 1939, in the eighth month of her first pregnancy with dyspnea, edema, weakness, absent fetal movements and frequent vomiting. Examination revealed marked cyanosis, râles at both lung bases and an enlarged heart with a to and fro murmur. There was a pitting edema of both legs; the fetal heart tones were absent. The patient died the day after admission because of heart failure and bronchopneumonia. At autopsy, chronic glomerulonephritis and chronic cholecystitis were found. This case was included on the basis of autopsy findings.

CASE IV. E. U., an eighteen year old colored female, was admitted August 16, 1940, with constant pain in the right subcostal region of the abdomen of six days' duration. The pain radiated across the epigastrium and to the right shoulder; there was no vomiting or diarrhea. The patient was greatly distressed by much eructation and "bloating." For one year she complained of a definite qualitative dyspepsia for fats but she denied any previous attack of pain. The patient had been married one and one-half years but had never been pregnant. Physical examination revealed a colored female in moderate distress, with a temperature of 100°F.; pulse 96; blood pressure 120/78 and a tenderness and rigidity in the right upper quadrant of the abdomen. A small, rounded, tense mass was palpable in the right subcostal region. The liver and spleen were not palpable. The laboratory data showed red blood cells, 4.1 million; white blood cells, 14,000; 89 per cent polymorphonuclears and the urine negative for bile. The stools were normal. The Kline and Kolmer tests were strongly positive. Cholecystectomy was performed on August 17, 1940. The operator reported that "numerous dense adhesions" were found, which "caused angulation and dyskinesia." The pathological report showed "chronic cholecystitis with early

acute cholecystitis." The patient left the hospital August 27, 1940 entirely free of symptoms.

CASE V. A. P. C., a nineteen year old white female and the mother of two children, was admitted August 18, 1940, complaining of an intermittent colicky pain in the right lower quadrant of the abdomen with radiations to her back. She had suffered similar attacks each month since her last pregnancy eleven months prior to admission. Each attack was accompanied by vomiting which seemed to relieve the pain. She gave no history of food dyscrasia, diarrhea or jaundice. During an appendectomy three months earlier, stones had been palpated in the gallbladder. Physical examination revealed a moderately sick colored female with a temperature of 98.6°F., blood pressure 160/100 and tenderness in the right upper quadrant of the abdomen. The icterus index was 16.5, blood cholesterol 275 mg. per cent, blood urea nitrogen 12.6 mg. per cent, and the stool examination was normal. Cholecystectomy was performed at which time stones were found in the gallbladder and the cystic duct. The wound was closed with drainage of the gallbladder bed. The pathological report was "chronic cholecystitis and cholelithiasis with Rokitsky-Aschoff sinuses in the wall." The patient, symptom-free, was discharged September 5, 1940.

CASE VI. S. M. P., an eighteen year old white female, was admitted August 14, 1941, with the chief complaint of vomiting and cramping epigastric pains, which radiated to the right shoulder. She had experienced three to four similar attacks during a period of six weeks prior to admission. The patient had been bothered by "eructation, flatus and indigestion" for a year. A self-imposed diet which she had followed during this time resulted in a weight loss of 38 pounds. Shortly before admission she developed an aversion to fatty foods and noted that at times her urine became highly colored. Physical examination revealed a temperature of 98.4°F., blood pressure 100/15 and a tenderness in the right upper quadrant of the abdomen. The laboratory data showed red blood cells, 4.2 million; white blood cells, 11,200; 72 per cent polymorphonuclears; icterus index 7; blood urea nitrogen 9.1 mg. per cent; cholesterol 150 mg. per cent and the prothrombin time was 80 per cent of normal. A cholecystogram showed good visualization with a 60 per cent emptying for a fat meal but there were multiple negative shadows in the gall-

## Heringman, Aiken—Cholecystitis

bladder. On August 28, 1941 cholecystectomy and choledochostomy were performed. The pathological report showed "chronic cholecystitis with mixed stones." On September 12, 1941, the patient developed a chill followed by persistent high fever. On September 19, 1941, *Escherichia typhosi* organisms were cultured from the blood and the draining bile. She gradually recovered and became afebrile October 15, 1941. The T-tube was removed on October 20, 1941 and the patient was discharged the following day.

CASE VII. A. L. J., an eighteen year old white female, was admitted August 5, 1943. Two weeks after the birth of her child (aged four months), she began to have attacks of colicky pain in the epigastrium and the right upper quadrant of the abdomen with radiations to the back and right shoulder. Each attack lasted several hours and was accompanied by nausea and vomiting. The pain was precipitated and aggravated by ingestion of greasy foods. She noticed no jaundice at any time, but gave a history of chronic constipation. Physical examination performed between attacks showed no evidence of biliary tract disease. The laboratory data showed no abnormality, except for the cholecystogram, which revealed positive and numerous negative shadows in the gallbladder. There was 50 per cent emptying. On August 17, 1943, cholecystectomy and choledochostomy were performed and many small stones were removed. The patient improved rapidly after operation and was discharged August 31, 1943.

CASE VIII. S. B., an eighteen year old colored female and the mother of one child, was admitted August 6, 1943, with radiating pain in the upper right quadrant of the abdomen as well as vomiting. She gave a history of appearing jaundiced several times during the four months prior to admission. She also experienced intermittent attacks of pain which were precipitated by ingestion of "cabbage and beans." Physical examination revealed an obese colored female with a temperature of  $100^{\circ}\text{F.}$ , and a tenderness in the right upper quadrant of the abdomen. The laboratory report showed hemoglobin 82 per cent; white blood cells 10,750 and 82 per cent polymorphonuclears. The urine was positive for bile and urobilinogen; the stools were normal. Blood chemistry revealed an icterus index of 25, cholesterol 185 and a prothrombin time of 71

per cent of normal. The cholecystogram failed to visualize the gallbladder. Clinical impression was cholecystitis with cholelithiasis but the patient refused operation and left the hospital August 13, 1943.

CASE IX. N. L. S., a sixteen year old colored female, admitted December 10, 1943, with cramping intermittent pain of five hours' duration in the right lower quadrant of the abdomen. She had experienced several similar attacks in the previous five months. The patient had been pregnant eighteen months prior to admission. She gave no history of any food dyscrasia. Physical examination revealed a temperature of  $101.6^{\circ}\text{F.}$ , pulse 104, blood pressure 140/84 with tenderness and moderate rigidity in the lower right quadrant. The laboratory report showed red blood cells, 3.3 million, white blood cells, 12,000, polymorphonuclears 76 per cent and normal stools. Appendectomy was performed but at operation it was found that the gallbladder was acutely inflamed and it was removed at the same time. The pathological report showed "chronic periappendicitis and chronic cholecystitis with Rokitsky-Aschoff sinuses in the wall." The patient was discharged December 21, 1943 after an uneventful postoperative course.

CASE X. D. H. A., an eighteen year old white female, was admitted January 30, 1944, complaining of frequent vomiting and constant pain of seventeen hours' duration in the right upper quadrant of the abdomen. One week previously she had suffered from a similar attack of pain which lasted only thirty minutes. The patient was married but gave no history of any pregnancy, food dyscrasia, constipation or jaundice. Physical examination revealed an obese white female with a temperature of  $101.8^{\circ}\text{F.}$ ; pulse 120; blood pressure 140/82 and tenderness in the right epigastric region. A flat plate of the abdomen showed no evidence of calculi. The laboratory findings were as follows: red blood cells 5.1 million; white blood cells 11,850; 89 per cent morphonuclears, the urine and stool examinations negative, icterus index 16.6 and cholesterol 111 mg. per cent. On January 30, 1944, appendectomy and cholecystectomy were performed. Fibrinous adhesions were found between the gallbladder and omentum but stones were not present. The pathological report showed "acute and chronic periappendicitis and early acute cholecystitis." The patient developed a wound abscess which

was opened on the tenth postoperative day. She was discharged February 20, 1944, entirely free of symptoms.

**CASE XI.** M. B., a nineteen year old colored female, was admitted March 31, 1944, with constant pain in the right side of her abdomen of sixteen hours' duration. She had vomited five or six times at the onset of illness. There was no history of jaundice nor of previous attacks of pain. The patient was in the fifth month of her first pregnancy. Physical examination revealed an obese colored female with a temperature of 99.8°F., pulse 108, blood pressure 116/80 and tenderness and rigidity in the upper right quadrant of the abdomen. The uterine fundus was at the level of the umbilicus. The laboratory work showed hemoglobin 73 per cent, white blood cells, 20,300, 96 per cent polymorphonuclears and other findings that were essentially normal. At operation the gallbladder was found to be tense, indurated, edematous and surrounded by numerous pericholecystic adhesions. The diagnosis of acute cholecystitis was made and cholecystostomy was performed. The tube was removed on the fourteenth postoperative day. She was discharged April 16, 1944 and her pregnancy terminated normally June 28, 1944.

**CASE XII.** J. W., a seven year old colored male, was admitted October 9, 1944, with intermittent abdominal pain of seven hours' duration. He had vomited three times since the onset of illness. There was no history of any previous attacks, no jaundice and no food dyscrasia. Physical examination revealed a colored child with a temperature of 98.8°F. and a pulse of 90. Abdominal tenderness was most marked in the right upper quadrant but was also present in the left upper and right lower quadrants. One examiner found that the gallbladder was "questionably palpable." The hemoglobin was 79 per cent, white blood cells, 11,000, 77 per cent polymorphonuclears and other laboratory findings were reported as normal. The preoperative impression was acute appendicitis, but at operation not only was the appendix inflamed but the gallbladder was found to be markedly distended by "cystic duct obstruction due to an inflammatory lymph node." Cholecystectomy and appendectomy were performed. The pathological report showed "slight subacute and chronic cholecystitis and acute appendicitis." The lymph node enlargement was caused by non-specific reticulum

cell hyperplasia. The patient was discharged October 25, 1944.

#### COMMENTS

From the material presented in this report, it appears that when all the cases presented in the literature are carefully evaluated, the incidence of acquired gallbladder disease in individuals below the age of fifteen is still low. The only patient in this age group (Case XII) was diagnosed as an acute appendicitis at operation. The incidental finding was a distended gallbladder caused by an enlarged lymph node obstructing the cystic duct. The pathological condition in this patient is very similar to that found by Seidler and Brakeley<sup>6</sup> in the case which they reported. The low incidence of cholecystitis in patients under fifteen years of age found in this group is substantiated by Bearse<sup>7</sup> in his report on sixty-three cases of gallbladder disease in patients under the age of thirty. Of these, there was only one patient below the age of fifteen and three below the age of twenty.

In general, young patients with biliary tract disease can be divided into three main groups according to the ages. In the neonatal period and very early childhood the congenital lesions of the biliary system are present. These include the various types of atresias and obstructions of the common duct due to inspissated bile.

In the late childhood period a number of cases of cholecystitis with or without cholelithiasis have been reported from time to time. In these patients there is usually a history of a preceding or intercurrent infectious disease; scarlet fever, diphtheria, influenza and typhoid fever have been frequently implicated. The importance of an infectious disease as an etiologic factor in the development of gallbladder disease in children has been emphasized by most of the authors who have written on this subject. It should be mentioned that acute inflammation of the gallbladder in this age group rarely progresses to suppuration. Usually the condition subsides sponta-

neously. For this reason, the diagnosis in children in all likelihood is frequently overlooked. Certainly it is possible that such patients may have a tendency to develop serious gallbladder disturbances at some later date.

The third period is that following puberty, or the very young adult (fifteen to twenty years of age). In this age group the disease is similar to that which occurs in older patients. Apparently the same relatively little known factors that are at work in older gallbladder patients can also be found in young adults.

The clinical picture in the reported cases was fairly typical. Epigastric and right upper quadrant pain with radiation to the back, nausea and vomiting, qualitative dyspepsia, eructation and flatulence were all prominent symptoms. To make the correct diagnosis in young individuals, clinical judgment is more important than laboratory evidence. Non-visualization of gallbladder was the most significant x-ray finding. In order to make an early, correct diagnosis in these patients, the clinician must have a high index of suspicion. If the possibility is not considered, the diagnosis will be missed and adequate treatment will be delayed.

There was no operative mortality in this series.

The high incidence of pregnancy in these patients is of great interest. Middleton,<sup>8</sup> Friedenwald<sup>9</sup> and others have emphasized the importance of pregnancy as a causative factor in the development of cholecystic disease in older age groups. Undoubtedly it also plays a significant rôle in those patients under the age of twenty. In fact,

a number of the patients seemed to date their illness from their pregnancy.

#### SUMMARY

1. Twelve cases of cholecystitis and cholelithiasis in the young are reported.

2. The pertinent literature has been reviewed.

3. Adult factors, such as pregnancy, play an important rôle in the development of gallbladder disease despite the fact that these patients were under twenty years of age.

4. Cholecystitis in childhood (below the age of fifteen) is still an infrequent condition but is not as rare as was formerly believed.

5. Cholecystitis in females between the ages of fifteen and twenty is not at all infrequent.

6. Greater attention to this problem will result in earlier diagnosis and better treatment.

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# CONVULSIONS DURING INHALATION ANESTHESIA

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CONVULSIONS during inhalation anesthesia are one of the most disconcerting complications which a surgeon encounters. They are also one of the most serious complications since the mortality rate may be as high as 20 per cent.<sup>1</sup> They are not very common although like many supposedly rare conditions there has been a considerable apparent increase in the number of cases since the initial reports of the condition in 1927.<sup>2-4</sup> Whenever they do occur the responsible surgeon as well as the anesthetist is always unhappy to be unacquainted and unprepared to meet the situation.

## SURGICAL ASPECTS

A study of surgical literature is rather disappointing but certain interesting facts are apparent. At first they were designated "ether convulsions"<sup>5,6</sup> but apparently all of the inhalation anesthetics have induced convulsions on occasion.<sup>7</sup> We were unable to find any report of a typical convulsion during intravenous barbiturate anesthesia.<sup>8</sup> Preoperative medication with barbiturates has failed to prevent the convulsion<sup>9</sup> although it is reasonable to expect them to have some prophylactic effect.<sup>10</sup>

In one instance<sup>11</sup> a patient had a four-minute convulsion during ether anesthesia which ceased spontaneously and the operation as well as the same anesthetic were continued uneventfully. In another instance a patient had a convulsion during ether anesthesia and a few days later had a second more serious and longer operation under ether without recurrence of the convulsions.<sup>12</sup> The same anesthetic solution and apparatus which were used when the convulsions occurred have been immediately used on another patient without convulsions developing.<sup>1</sup> Tests for significant impurities and toxicity of the ether used have been invariably negative.<sup>13</sup> No

cases in elderly people have been reported.<sup>14</sup> Many of the reported cases have been young females with a septic condition and fever, typically acute febrile appendicitis.<sup>15</sup>

One young patient had a convulsion during ether anesthesia for an application of a cast to a fractured os calcis, i.e., no operation was performed. Three weeks later an exploration of the bone under ether was uneventful.<sup>16</sup> Another child had a convulsion during ether anesthesia for an osteotomy for congenital dislocation of the hips. Six months later she had an uneventful nitrous-oxide-ethylene anesthesia for a second osteotomy. Two weeks after the second operation a brief nitrous-oxide anesthesia was associated with tetanic contractions. A few days later without anesthesia an increase in traction of the legs precipitated four generalized convulsions.<sup>17</sup> One surgeon reported two patients who had repeated operations and repeated convulsions.<sup>18</sup> Complete recovery is the rule but severe degrees of mental impairment or paralysis may follow.<sup>19</sup> A high fever (106°F.) has been noted in a number of subjects but hyperpyrexia is a common feature of the convulsive state and therefore is not necessarily an etiological factor. The convulsions have occurred early during anesthesia and also after discontinuance but have most commonly developed late in a prolonged anesthesia.<sup>20</sup> Vinesthene seems to be the worst offender,<sup>21</sup> one report stating that the nurses in the recovery ward came to regard the convulsions as an unimportant normal complication.<sup>10</sup> The mortality rate increases with the duration and severity of the convulsions. It has been suggested that the convulsions are Jacksonian in type beginning with a twitching of the facial muscles.<sup>22</sup> This seems questionable since they have not been described as starting in any other part of the body.



The apparent origin in the facial area is probably explained by the fact that the face is the only part of the anesthetized patient which is under careful observation.<sup>23</sup> Alert surgeons have warned of the imminence of convulsions by the pushing up of the intestines during laparotomy. No prodromal features such as difficulty of induction, etc., have been described as useful warning signals.

#### NEUROLOGICAL ASPECTS

The neurological literature was more informative although not much was specifically found concerning convulsions during anesthesia.<sup>27</sup> Neurologists plainly state that which is apparent from a study of the surgical literature, that the cause and nature of the convulsive state is not known. Thus it may be said that until some rational explanation is offered as to why and how an epileptic person may have a convulsion while walking down the street, apparently in otherwise perfect health, it will be difficult to explain convulsions during anesthesia. However, certain features of the convulsive state are known and may have practical bearing on the surgical problem.

Electroencephalography has shown that approximately 12 per cent of the population have significant electrical action current waves similar to those found in about 75 per cent of epileptics.<sup>28</sup> A group of twenty-two patients who had had convulsions under anesthesia also showed 73 per cent to have similar abnormal waves. A study of a group of patients with puerperal toxemia showed the eclamptics to have a similar high rate of abnormal waves in comparison with the so-called pre-eclamptics who did not have frank convulsions.<sup>28</sup> Individuals with such abnormal electroencephalographic waves are presumably more susceptible to convulsions from whatever excitants. There is great individual variation in susceptibility to the dose of convulsive drugs such as absinthe, insulin, metrazol and electric shock.<sup>29</sup> Some people who faint develop convulsions if not allowed to promptly attain a horizontal

position. This is probably a manifestation of the convulsive effect of anoxia. The hypocalcemia of the alkalosis of hyperventilation produces tetany which may predispose to convulsions. The delirium of fever attains convulsive vigor in some persons, especially in infancy.

#### ETIOLOGICAL THEORY

Many reasons have been advanced as to the cause of convulsions during inhalation anesthesia.<sup>24</sup> Most of these so-called causes do not deserve repetition here. Many of them are patently absurd, obviously concomitant variations, unprovable theories or at least subject to the Scotch verdict "not proven." Coincidental idiopathic epilepsy can not explain many of the cases since a history of epilepsy is rarely obtained. When unsedated epileptics have one of their fits during anesthesia it is usually during the induction stage.<sup>25</sup> Rosenow's theory of the fortuitous coexistence of a subclinical infection with a streptococcus of strong neurotropic propensities cannot be disproven and probably explains some cases. There seems to be no single factor or combination of factors invariable enough to qualify as the cause of the convulsions except the salient fact of the inhalation anesthetic. Similarly there seems to be no specific precaution to be taken against the convulsions other than the fact that the patient should be given the benefit of good surgical judgment in all respects.

Whether considered a constitutional predisposition or by whatever name designated, it seems established that some people have convulsions more easily than others. If these people could be positively identified preoperatively the anesthetist and surgeon might be forewarned. Electroencephalography is not an accurate determiner and a history of convulsions is not often found. It is even better established that certain states of pathological physiology can sometimes induce convulsions. Among these are alkalosis, anoxemia, hyperpyrexia, azotemia and intoxication from certain drugs known as convulsants.

We suggest that the inhalation anesthetics should be considered as weak facultative convulsants. Divinyl ether (vinesthene) is a considerably stronger convulsant than the ordinary di-ethyl ether. They are such weak convulsants that only in certain predisposed individuals under certain contributing irritative conditions can they produce convulsions. To consider ether as a convulsant is contrary to ordinary concepts but seems justified. Metrazol (pentamethylenetetrazol) is perhaps an analogous drug. Originally introduced as a central stimulant for respiratory and circulatory support in emergencies there came a time when it was particularly used as a convulsant in treating psychoses. Convulsions under anesthesia, therefore, may be determined in a small part by a predisposition of the individual and by certain known aggravating factors, including a weakly convulsant drug, but in greater part they are determined by the same unknown factors of cause and nature common to the convulsive state in general.

#### THERAPY

The therapy for convulsions when they appear is directed primarily at the palliation of the convulsions.<sup>30</sup> The convulsion state is dangerous.<sup>31</sup> The act of respiration is suspended during the convulsions with consequent anoxia and cyanosis of severe degree. A vicious circle is instituted because anoxia of the brain predisposes to convulsions. The convulsive dose of absinthe for instance is less when the animal is cyanotic. The nervous tissue of the brain is easily injured by anoxia and permanent damage may be produced. The convulsions are best controlled by the intravenous barbiturate anesthetic sodium pentothal. As soon as a convulsion occurs the inhalation anesthetic should be discontinued, oxygen administered by the anesthetic machine and a solution of sodium pentothal injected intravenously. The dose is the amount necessary to control the convulsion. As little as 10 cc. of 2.5 per cent solution has been successful<sup>30</sup> but larger doses may be

necessary. Intratracheal intubation should be done so that artificial respiration can be maintained. The operation should be concluded as soon as practical, closing the abdomen simply with several through-and-through stay sutures for instance; if the convulsions persist their violence can be reduced by intocostin. It should be remembered that the dose of intocostin is much less in the presence of ether anesthesia. The hyperpyrexia should be reduced by cold compresses. General supportive measures may be indicated for shock such as intravenous fluids and vitamins. Oxygen may be given by tent or mask for some time after the convulsions have ceased. Death has resulted from late pulmonary complications<sup>32</sup> so bronchial aspiration through the bronchoscope and prophylactic penicillin may be desirable.

#### CASE REPORTS

CASE I. The first of these has been reported by Tovell<sup>33</sup> (Case III) and was not a severe generalized convulsion but rather a muscular jerking which so alarmed the surgeon that operation was postponed.

CASE II. The second case was a young girl with acute febrile appendicitis. The convulsions occurred while the abdomen was being closed and responded promptly to intravenous sodium amytal. The postoperative course was quite normal. The anesthetic had been induced by an experienced nurse anesthetist with a nitrous-oxide and oxygen mixture and maintained smoothly with ether and oxygen on a Lundy-Heidbrink machine with a carbon-dioxide absorber. Preliminary medication had been pentobarbital, morphine and atrophine.

CASE III. This case was a twenty-three year old muscular, male negro with a small old afebrile appendiceal abscess. The convulsions appeared after approximately twenty-five minutes of anesthesia. The patient had taken the anesthetic very poorly and the inexperienced nurse anesthetist had resorted to an open ether mask. Preliminary medication was pentobarbital, morphine and atropine. The operation was performed in the evening; the convulsions were brief but violent and the patient promptly died. There was some question of the death

being simply a matter of an overdose of ether but the convulsion was the significant intermediate event. Necropsy permission was denied.

CASE IV. Mrs. F. W., aged twenty-three, white, a housewife dependent of a soldier. She entered the hospital on July 8, 1943 at 3:00 A.M., complaining of abdominal pain of forty-eight hours duration. The pain was severe and the patient was nauseated. The past history contained no serious illnesses, operations or injuries of note. A recent pregnancy had produced a healthy boy now nine months old for whom the breasts were still lactating. There was no familial or past history of allergy, convulsions or drug idiosyncrasies. On admission the temperature was normal. There was localized tenderness and guarding in the right lower quadrant of the abdomen. The blood pressure was 130 mm. of mercury systolic and 74 diastolic. The patient said she was 63 inches in height and weighed 145 lbs. She was bright and intelligently cooperative. The laboratory reported a negative urinalysis with a specific gravity of 1.032. The blood showed 10.9 Gm. of hemoglobin per 100 cc. with 3,500,000 erythrocytes per cu. mm. No explanation for this anemia was apparent. The leukocytes were 12,050 per cu. mm. and 90 per cent polymorphonuclears.

By 8:00 A.M. the fever had risen to 100.2°F., with a pulse rate of 90 per minute; a diagnosis of acute appendicitis was made. The anesthetic for appendectomy was started at 9:00 A.M. Preliminary medication was morphine sulfate 10 mg. and atropine sulfate .15 mg. given about 8:45 A.M. The anesthetic was induced by an experienced nurse anesthetist with a nitrous-oxide and oxygen mixture on a Lundy-Hcidbrink machine, switching soon to ether vapor in oxygen with a carbon-dioxide absorber. The anesthetic was accepted well and the patient was quite relaxed.

The operation was very difficult. The appendix was completely retrocecal and gangrenous. After approximately sixty minutes of anesthesia the patient suddenly had a severe generalized convulsion of variable intensity lasting thirty minutes. The temperature rose to 106.2°F. by axilla. Cyanosis was often deep in spite of discontinuing the ether and supplying pure oxygen. The operation was promptly terminated with a drain through a stab wound in the flank. Shock developed with the blood

pressure falling to 60 systolic and 0 diastolic, the pulse was 150 and the respiratory rate 34. No intravenous barbiturate solution was available. Supportive therapy was applied, 500 cc. of preserved plasma and 1,000 cc. of 10 per cent glucose in normal saline solution intravenously and caffeine and adrenalin were given. The patient was returned to her bed at 10:45 A.M.; oxygen was continued by B. L. B. mask and ice bags were applied to the limbs. She vomited at 11:45 A.M. and the anesthetist's airway could be removed. Her temperature had fallen to 101°F. rectally with pulse of 136, respiration 36 and blood pressure 110/75. She continued to have epileptiform convulsions every few minutes lasting for one-half to eleven minutes. These convulsions might occur spontaneously or be precipitated by minor stimuli such as a mere touch of the nurse's hand. She was incontinent; the breathing was deep and heavy suggesting acidosis so insulin and glucose were given intravenously. At 6:00 P.M. 3 gr. of sodium phenobarbital were given intravenously. Following this she was quieter and the pulse slowed to 88 but the respiration remained at a rapid 30 and she continued to have convulsions every half-hour lasting for several minutes.

At 1:00 A.M. of the first postoperative day she started to move her arms and legs and began to groan occasionally. All reflexes were very hyperactive with opisthotonus. Urine examination showed a specific gravity of 1.020 with albumin grade 3 (on the basis of 4), sugar grade 4 (due to intravenous glucose?) acetone and diacetic acid grade 3, an occasional granular cast and leukocyte but no blood. Blood chlorides were 560 mg. per cent and non-protein nitrogen was 43 (both slightly elevated). Phenobarbital was given repeatedly in 3 gr. doses intramuscularly but the convulsions continued to recur at longer intervals and less violently. The spinal fluid was under normal pressure and contained no blood but the total protein was 65 mg. per cent. The blood sugar was 105 mg. Thirty hours after the operation her general condition seemed improved although her temperature was 102°F. The pulse varied from 100 to 150 and the respirations 38 to 50. The pupils were dilated but equal and reacted to light. The fundi appeared normal. The reflexes continued to be hyperactive but were equal on the two sides. Muscular rigidity

and twitching were notable even between convulsions.

During the second postoperative day her condition continued to be serious although the convulsions ceased in about forty hours. The fever persisted at 102°F., the pulse ranged from 120 to 140 and the respirations were 40 to 48. The reflexes changed to hypoactive and the pupils did not respond to light. She vomited several times and opisthotonus was still noted when the nurses moved her. Calcium glueonate was given intravenously without evident effect. Thiamine hydrochloride was started, 100 mg. intramuscularly three times a day. She developed a slight cough so carbon dioxide inhalations were given every four hours.

By the end of the first postoperative week she had improved somewhat. She moved her arms and legs and began responding to simple nursing instructions. She recognized her husband on the sixth day. Sustenance was maintained by intravenous solutions in large quantities. She did not speak and had difficulty in raising sputum. The fever continued at about 102°F. There was considerable purulent discharge around the surgical drain.

During the second postoperative week she began to accept nourishment by mouth. Sulfadiazine was given to maintain a blood level of 12 mg. per cent. There was still a tendency to opisthotonus and she was aphasic. She would smile and grimace on instruction and cooperated fairly well at times; at other times she would become restless, agitated and negativistic. She was not distended at any time. A fever of 102°F. continued with commensurate pulse and respiration. Purulent drainage continued from the drainage wound and the incision also began to drain. She had difficulty in swallowing sulfadiazine tablets.

During the third postoperative week a disuse contracture of the right arm was noticed. Extension was limited to 145 degrees. Her fever continued a septic course rising to 102°F. at which time she would become delirious and incontinent. At times she would babble incoherently for an hour or so; at other times she would ask intelligently for attention and seemed quite well oriented. She was able to speak a few words slowly with great difficulty. The difficulty in swallowing continued as did the cough. Several transfusions of citrated blood were given.

During the fourth week the right colic gutter was explored through a flank incision under local infiltration anesthesia with procaine and a large abscess was drained. The fever promptly subsided and her mental status improved considerably. She still had difficulty in speaking and swallowing and the cough persisted. The speech impairment seemed to be a groping for words as if there were some interruption in the speech pathways in the brain, although it was found she had a symmetrical paralysis of the palate which explained her difficulty in swallowing and dysphonia. The tongue was also partially paralyzed. She could work crossword puzzles with celerity; she had been adept at this before her convulsions.

During the second month of hospitalization her mental faculties cleared nicely. The wounds continued to drain but finally closed. A fecal fistula was evidently present for a short time. Her pharyngeal paralysis persisted and it was thought that her irritative cough was due to inhaling pharyngeal mucus. There was no headache. The contracture of the right arm (biceps) improved but extension was still incomplete. With excitement she became quite incoherent but when she spoke slowly and carefully her speech seemed quite normal. She was dismissed from the hospital on August 30, 1943.

She reported by letter nine months later that the contracture of the arm had completely disappeared. She spoke quite normally but still had some difficulty in swallowing. She did not have any significant headache. Apparently there had been no change in her personality.

#### COMMENT

The failure of phenobarbital to completely relieve the convulsions was a disappointing feature of the case. It is possible that larger doses would have been more effective.

#### CONCLUSIONS

1. The fundamental nature and cause of convulsions is unknown both during and without inhalation anesthesia.
2. It is suggested that the drugs used for inhalation anesthesia should be regarded as weak facultative convulsants which

precipitate convulsions in certain predisposed individuals.

3. Probably the most effective prophylactic is the use of a barbiturate as preoperative medication.

4. Treatment of the convulsion is also probably best accomplished by intravenous barbiturate (sodium pentothal) anesthesia and general supportive measures.

5. A case is presented with residual glossopharyngeal paralysis.

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# THE UNDERDEVELOPED CHIN

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IN a previous article<sup>1</sup> sixteen cases of preserved rib cartilage chin implantations were reported; since then, an additional fifteen transplantations were performed. It is the purpose of this paper to supplement the previous report.

Plastic surgeons will agree that the majority of patients with receded chins seek consultation for nasal correction. In the course of examination, the surgeon examines not only the patients' nose but also the other facial features and the general stature. A critical survey is made. The forehead, nasofrontal angle, nasal projection, nasolabial angle, superior maxilla, dental projection and chin are observed. Individual analysis is made as each face is a unique one. The patient is observed in the relaxed, smiling, laughing and speaking positions. One searches for defects and singles out those facial characteristics which are not in proportion. One or more malfeatures may be present and may or may not lend themselves to satisfactory esthetic correction. With the exception of the nose, deformities of the chin are the most common facial malformation.

A chin which appears to be underdeveloped requires careful study before a true diagnosis of microgenia is established. Frequently a micrognathic appearing lower jaw is not receded. It may appear small but this may only be an apparition, especially if the upper teeth are "bucked" or protrude too far in advance of the lower jaw. A chin is underdeveloped only when it is out of proportion with the other facial features.

The nose plays an important rôle in chin corrections. A prominent nose with a webbed nasolabial angle can create a small lower jaw illusion. A humped or long nose may accentuate a minor chin recession.

The mere lifting of a nasal tip can remove the emphasis from a mildly protruded or receded chin. In certain instances, the "mouth breather" appearance is eliminated by reducing the nasal profile and elevating the nasal tip without chin correction.

Occasionally where a prominent long nose and apparent receded chin are present concomitantly, one is uncertain prior to operation whether or not a chin correction is necessary. At operation, the nose is first corrected and then the chin if deemed necessary.

## CLASSIFICATION OF THE UNDERDEVELOPED CHIN

From a didactic point of view, hypoplastic chins may be classified in five types: (1) Underdeveloped in a superior to inferior direction due to decreased height of the body of the mandible or absence or recession of the lower teeth; (2) underdeveloped in a lateral to lateral direction due to decreased width of the body of the mandible; (3) underdeveloped in an anterior to posterior direction due to dwarfing of the mental protuberance, absence of the mental tubercles, shortening of the horizontal rami or a posterior dislocation of the temporomandibular joints; (4) underdeveloped unilaterally due to a unilateral first branchial arch and cleft malformation or a unilateral dislocation of the temporomandibular joint, and (5) underdeveloped in a combination of two or more of the above.

From a surgical point of view, three types of chin recessions are noted depending upon their degree.

1. *Mildly Receded.* If the nose and other facial features are in proportion, a chin correction may not be necessary. If



FIG. 1. A and B, preoperative photographs; C and D, postoperative photographs after combined rhinoplasty and thin preserved rib cartilage chin implantation.

the nose is prominent, hooked or long, nasal correction combined with a thin preserved rib cartilage chin implant may be indicated. (Fig. 1.)

2. *Moderately Receded.* The lower teeth are usually receded giving a "buck tooth" appearance. The deformity is accentuated when smiling or laughing. The patients are self-conscious and employ compensatory cover-up mechanisms such as hiding the face with the hands or turning away

while expressing their emotions. During childhood, orthodontics is the method of treatment. After puberty, if esthetic improvement is desired, a thick preserved rib cartilage graft may be inserted into the chin to bring the glabella and mentum into a perpendicular line. (Figs. 2 and 3.)

3. *Markedly Receded.* This exaggerated deformity gives a comical expression to the face. Stage and movie comedians and circus clowns often burlesque it. Masks and false





FIG. 2. A and B, preoperative photographs; C and D, postoperative photographs after combined rhinoplasty and thick preserved rib cartilage chin implantation.

faces used at parties and Mardi Gras imitate it. The patient suffers repeated cruel ridicule. To improve the appearance and dental occlusion simultaneously, an osteotomy through the horizontal ramus with advancement of the lower jaw may be performed. Satisfactory esthetic improvement may be obtained by the mere insertion of one or more thick preserved rib cartilage grafts. (Figs. 4 and 5.)

**Age.** Medical men tend to discourage their patients from esthetic facial corrections until they are eighteen years of age or over. A careful study of adolescents

will show that the majority of girls are fully developed between the ages of thirteen and fourteen; the breasts are full grown, the ovaries are functioning and the secondary sex characteristics are complete. The final adult facies is attained at the same age.

This period is the ideal time for facial plastic surgery as one need not fear further changes of the facial characteristics. The patients can well tolerate the surgery and make excellent and rapid recoveries. At this age most girls begin secondary school. If a facial deformity is present





FIG. 3. A, preoperative photograph; B, postoperative photograph after combined rhinoplasty and thick preserved rib cartilage chin implantation.

which the patient wishes corrected, the operation should not be denied. It should be performed before entering the new school and beginning a new phase of life.

Boys mature at a later age. Their facial features are not fully developed until the ages of fifteen or sixteen. Should one be in doubt, procrastination is best. However,

when the features appear to be developed, considering the body as a whole, the operation should not be delayed.

#### TECHNIC

Of all the various procedures in plastic surgery, the preserved cartilage transplant for a receded chin is perhaps the most



FIG. 4. A, preoperative photograph; B, postoperative photograph after combined rhinoplasty and thick preserved rib cartilage chin implantation.



FIG. 5. A and B, preoperative photographs; C and D, postoperative photographs after combined rhinoplasty and very thick preserved rib cartilage chin implantation.

simple, most rapidly performed and most gratifying of all operations. Preserved cartilage is readily obtainable in large quantities; it is kept in readiness in a sterile solution and is easy to model. Foreign body reactions from preserved cartilage implanted into the chin are a rarity.

In most instances, a rhinoplasty is performed concomitantly with the chin plastic. The nose is first corrected and

strapped in position; a cast is not applied to the nose so that all the facial components may be freely visible for the chin correction. The gowns, drapes and gloves are changed; the face, chin and neck are again surgically prepared; another set of sterile instruments is employed; guide lines are drawn. The cartilage is modeled to size, all sharp corners being beveled. The anterior surface may be flat as the mentum pad maintains the graceful fullness of the

chin. Procaine with suprarenin is injected and the cartilage inserted through a small submental incision. The incision is closed and a firm pressure dressing is applied. A cast is then modeled to the nose.

The pressure bandage is removed from the chin on the fifth day; upon removal, the chin is insensitive and appears too large. The swelling, however, rapidly recedes. The sensitivity begins to return after a month and is usually complete after three months.

#### COMPLICATIONS

Failures or untoward results after preserved rib cartilage chin transplantations are not common. Certain complications, however, may take place

1. *Perforation into the Oral Cavity.* This may occur in the course of undermining the skin over the mentum. If this happens, the submental incision may be closed and the operation terminated. It may then be repeated a month later. However, the cartilage may be implanted even after oral perforation if penicillin is administered concomitantly. Infection does not usually occur.

2. *Displacement of the Graft.* This may occur if a tight immobilization bandage is not applied; it occasionally takes place despite it. Extensive undermining or an accidental blow before the cartilage is firmly fixed can displace the graft. A secondary operation is then necessary. The cartilage is liberated and replaced in its proper position.

3. *Infection.* Infections from preserved rib cartilage chin transplants are not common. They occur more frequently after autogenous transplantation of the nasal hump or septal cartilage and bone. In this series, one mild infection occurred which healed spontaneously in a few days without specific treatment.

4. *Vesicular Dermatitis.* This is quite commonly found on the skin of the chin after the removal of the pressure dressing. Specific treatment is unnecessary as the vesicles disappear in a few weeks.

#### COMMENTS

The microgenic chin is a common facial deformity. Satisfactory esthetic results are obtained by preserved rib cartilage transplantation. The operation is simple, requires little skill and entails a minimum of risk.

Every individual with an underdeveloped chin who presents himself for nasal correction should have the merits of preserved rib cartilage chin correction explained. As a rule, patients with hypoplastic chins are frightened and reluctant to undergo chin correction, but they are not averse to the procedure after the rapidity and simplicity of the operation is explained.

If the facial features are in harmony, with the exception of a receded chin, preserved rib cartilage chin transplantation gives a satisfactory cosmetic result. If a nasal and chin plastic are performed concomitantly, the esthetic results are often spectacular. An unpleasant facial contour is transformed into a highly desirable one.

#### CONCLUSION

Preserved rib cartilage was transplanted into microgenic chins in thirty-one instances. In all save one the recovery was rapid, uneventful and gratifying. A single case of infection occurred but healed spontaneously in a few days without specific treatment.

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# TOPICAL ANESTHESIA\*

## EFFECT ON TISSUE REGENERATION

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PHYSIOLOGISTS are generally agreed that there are certain prerequisites for normal repair of injured tissues. These are adequate amounts of ascorbic acid, equilibrium of serum proteins and normal carbohydrate metabolism. According to Holten and Crile, Jr., there is little evidence that a good physical condition and vitamins other than ascorbic acid are necessary.<sup>1</sup>

However, in recent years there have been indications that local anesthesia may play a significant part, especially where pain is a prominent factor. Leriche<sup>2</sup> believes that anesthesia is important since trauma initiates an excitation of nerve impulses along vasomotor afferent neurons which produce excessive vasodilatation, with edema, pain, tenderness and muscular spasm. If pain is eliminated there is, therefore, destruction of the impulses which emanate in autonomic waves from traumatized areas with a subsequent return of vasomotor tone, thus effecting normal autonomic equilibrium.

Cullumbine, Rice and others<sup>3</sup> have treated minor fractures with 1 or 2 per cent solutions of procaine hydrochloride injected into the fracture site. It was observed that better alignment of bones was obtainable under good local anesthesia, pain was promptly relieved, the patient was able to walk immediately in many instances and healing was rapid.

Excellent results have been reported<sup>4</sup> following single injections of similar solutions

into sprained joints and torn ligaments. Most of the patients were able to use the injured joint immediately; only few required an additional injection. Apparently the procaine hydrochloride prevents the vasodilatation and edema responsible for pain and disability.

Rivaz-Diez and Delrio<sup>5</sup> discuss the use of local anesthetics in the therapy of burns. They use four methods: local anesthesia in small burns, nerve block in larger burns of the extremities, intravenous injections of procaine in extensive burns and intra-arterial injections of a procaine hydrochloride solution. They found that with diminution of circulatory congestion, edema and exudation, not only was the pain less intense but the rate of epithelization was accelerated.

It has been repeatedly demonstrated that chemicals are more potent cutaneous sensitizers when applied in concentrated solutions. Therefore, an ointment was used which contained less than 1 per cent of the para-aminobenzoates.<sup>6</sup> A small quantity of cod liver oil was added for its healing and analgesic properties.<sup>7</sup> Cod liver oil stimulates granulation tissue and its use is almost invariably followed by soft, supple cicatrices. Although some authors have attributed many of the benefits of the oil to its bacteriostatic action, Goertzen<sup>8</sup> has shown experimentally that it is not germicidal. He believes the healing effects of cod liver oil are due to its ability to protect the tissues against dehydration and to

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promote granulation tissue. The antiseptic properties of the ointment were enhanced by the presence of sodium propionate.<sup>9</sup>

Since burns and hypostatic ulcers offer the most convenient example of painful cutaneous lesions, and since both in many respects present identical chemopathological changes they were selected to determine the effects of a local anesthetic ointment on tissue regeneration.

In view of the possibility of cutaneous irritation from the aminobenzoates, sixty subjects were tested according to Federal Trade Commission recommendations (240 patches) for primary irritation and hyperallergization. Only one patient reacted positively to the ointment. Patch tests were done with the various ingredients and this patient was found to be sensitive to benzyl benzoate.

**Procedure.** One hundred three patients were treated; sixty-six had burns of varying degree. In no instance did the burn involve more than one-eighth of the body surface. Débridement was performed after cleansing the area with tincture of green soap prior to application of the ointment\* and a sterile dressing. The patients were instructed to return to the clinic in twenty-four hours for observation. The outpatients were redressed twice weekly and hospitalized patients were dressed as necessary (one to three times weekly). All the patients treated for burns were comfortable and able to work throughout the treatment time.

\* An ointment of the lipophilic type was used in this investigation and was designated "S. P. 901." Its composition was as follows:

Lanolin.....	25.
Petrolatum.....	25.
Water.....	15.
Iso-beeswax.....	8.
Cod liver oil.....	20.
Corn oil.....	5.
Amyl para-amino benzoate.....	0.7
Ethyl para-amino benzoate.....	0.2
Benzyl benzoate.....	1.
Sodium propionate.....	2.

This ointment was supplied by Chatham Pharmaceuticals, Inc., Newark, N. J. and corresponds to their product, Ultracain.

Thirty-one patients suffering from ulcers due to various causes were treated with the ointment, which was applied directly to the ulcer and any surrounding dermatitis. The dressings were changed once or twice weekly. If necessary, the individual was

TABLE I  
BURNS

Type	No. of Patients Treated	Average No. of Treatment Days	Extremes
1st degree.....	15	4.0	2-7 days
2nd degree.....	49	11.4	5-21 days
3rd degree.....	7	21.5	7-35 days
Mixed.....	5		

ULCERS

Hypostatic.....	25	34	7-90 days
Traumatic.....	4	14	7-28 days
Pyogenic.....	1	42	
Sickle cell.....	1	no effect	

hospitalized. Patients with vascular insufficiency were encouraged to wear an elastic bandage.

When the epidermis had completely regenerated, even in the presence of some erythema, the wound (burn or ulcer) was considered healed and no longer in need of topical therapy.

**Results.** Every patient reported relief of pain at the site of the burn or the ulcer immediately upon application of the ointment. We observed no infection during the course of treatment. The scars were soft and pliable with very little evidence of contracture even in third degree burns. No adverse reactions to the ointment were encountered when its use was restricted to denuded areas. The healing time impressed us as being unusually short. Table I. Of the sixty-six patients treated for burns, only one developed a surrounding dermatitis. This patient was a child who was cared for at home in an unclean environment. Three patients with ulcers were irritated by the ointment; (one with a

hypostatic ulcer developed a vesicular dermatitis after the ulcer had healed; one patient complained of subjective discomfort but there was no evidence of dermatitis; the third patient developed a dermatitis on continued use of the ointment two months after the ulcer had healed). Patch tests with all ingredients were negative in these patients.

#### COMMENTS

It is important to note that the amino-benzoates present in a concentration of 0.9 per cent were able to produce immediate and adequate topical anesthesia. Most previous reports dealing with the use of para-aminobenzoates as topical anesthetic agents were based on the use of solutions or ointments containing more than 2 per cent of these drugs.

In this series of 103 patients, there were no infected wounds (burns or ulcers) during the treatment period, although many of the burns were not seen until several days after their occurrence. These were treated as fresh burns; cleansed thoroughly with green soap and followed by a sterile dressing of ointment. The inhibition of bacterial growth by the ointment no doubt was responsible to a large extent for the relatively short healing time.

First degree burns, where only the epidermis was damaged, healed in two to seven days, depending upon the extent of the injury. Second degree burns showed signs of epithelization as early as five days after treatment was started. In the deeper burns and ulcers, epithelization was more rapid peripherally than centrally. The longest healing time was thirty-five days, except in one patient whose burn was severe and extensive, including the entire anterior tibial region and knee. The area involved to secondary degree was healed within thirty-five days, whereas the more deeply burned area around the knee was just about to epithelize at this time. Pinch grafts were then applied, the resulting scar being soft and supple.

Only four of 103 patients developed a dermatitis, all of them having continued use of the ointment after the ulcer or burn had healed. These patients were patch tested to each ingredient of the ointment and reacted negatively to all. No dermatitis developed during treatment while the area was denuded.

#### SUMMARY

1. Many investigators have shown that anesthesia plays a significant part in the promotion of healing.
2. Sixty-six patients with burns and thirty-one patients with ulcers were treated with an ointment containing less than 1 per cent of aminobenzoates.
3. Healing was rapid and scars soft and supple.
4. No infection was observed during treatment.
5. No irritation occurred regardless of the length of time that the ointment was used on the broken skin.
6. Of the 103 patients treated and 240 patch tests, no cases of benzocaine sensitivity were seen.

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MANY minor operations in the mouth can be performed under local anesthesia, but if the operation is expected to occupy some length of time and bleeding to be free it is wiser to give a general anaesthetic, preferably with the introduction of an intratracheal catheter.

From "Minor Surgery" edited by Humphry Rolleston and Allan Moneriet (Philosophical Library).

# ABDOMINAL SYMPTOMS IN SUDDEN ACUTE HEART CONDITIONS

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THE occurrence of abdominal symptoms in sudden, acute coronary conditions is known to all, but its incidence is not always appreciated. Whereas the signs and symptoms of typical acute heart disease and typical abdominal pathological conditions offer little difficulty in differential diagnosis, a number of borderline cases occur in which the correct diagnosis is seriously in doubt, often for a matter of hours, and even completely missed.

Since immediate lines of treatment are indicated in both sudden, acute heart conditions and acute abdominal disease, a discussion of the pathologic physiology and some of the diagnostic aids of these situations is valuable.

The subject of abdominal and thoracic viscus pain has been discussed thoroughly since the turn of the century. Of these two entities abdominal pain perhaps has been most written about due to greater surgical opportunities to make observations in this area of the body. While the works of Ross,<sup>1</sup> Lennander,<sup>2</sup> MacKenzie<sup>3</sup> and Hurst<sup>4</sup> do not agree entirely on whether or not visceral pain originates in the somatic nerve terminals of the parietal peritoneum or the bowel, or whether all visceral pain is of the referred type, it has been generally accepted that in whatever form this pain exists, it is carried by the afferent fibers of the splanchnic nerves. Phenomena such as nausea and feelings of tension are the sensory properties of the vagus and its branches.

The same differentiation holds true for the sensory impulses of the heart. Pain is carried by afferent fibers of the superior, middle and inferior cardiac nerves and not the vagus.

The anatomy of the splanchnic and cardiac nerves have many features in common.<sup>5</sup> They are both derived from lateral

horn cells (intermediolateral cell column) of the spinal cord and are associated with outlying ganglia which comprise the sympathetic system. Efferent fibers of this system are preganglionic, medullated fibers which synapse in vertebral ganglia and emerge as postganglionic unmedullated fibers. The afferent fibers accompany almost in full accord, as to anatomical relation, their motor counterpart. Thus they enter the cord at the same level that the efferent fibers of their respective organs left. The afferent fibers arising directly in the organ have their cell body in the posterior root and have their synapse in the grey matter of the cord and ascend for the main part in dorsolateral fasciculus or tract of Lissauer.

The superior, middle and inferior cardiac nerves are derived from the corresponding cervical ganglion but their cells of origin for their preganglionic fibers arise in the upper four or five thoracic segments of the cord. There are three divisions of the splanchnic nerves: greater, lesser and least, so named after their respective size. The greater splanchnic in some individuals can arise from the cord as high as the fourth or fifth thoracic segment.<sup>6</sup> The other two splanchnics arise down to the eleventh thoracic segments.

Thus it is evident that pain sensations from two unrelated systems as the heart and upper abdominal contents can bombard the spinal cord in two complete and identical segments.

As stated before, most observers agree that nausea and vomiting are the result of afferent vagus impulses ending in the dorsal nucleus. The anatomy of the vagus nerve is familiar to all, namely, that of an elongated main stem extending from the fourth ventricle through the neck and



thorax, ending in the mid-abdomen. Branch divisions to the heart and the abdominal viscera arise from this main stem. It is certainly not difficult to conceive of a sudden, overwhelming stimulus occurring in the heart irritating abdominal fibers

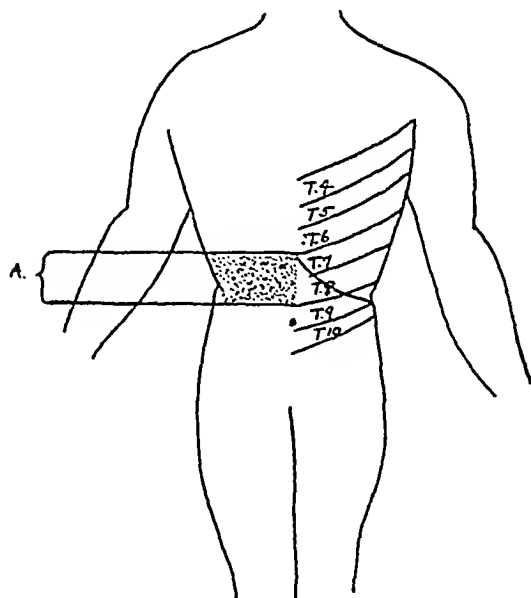


FIG. 1. Dermatomes of the human body; anterior aspect.

contained in the same nerve stem with those cardiac fibers for which the stimulus was intended.

In addition to deep pain, nausea and vomiting occurring as abdominal manifestations of acute cardiac conditions, signs of actual muscular rigidity and peripheral hyperesthesia are encountered in some cases. Assuming the theory of Mackenzie or viscerosensory reflexes is correct (it is not the purpose of this paper to prove or disprove the subject of referred pain), the work of Head<sup>7</sup> explains these misplaced phenomena. The basis of his work is the embryological development of the dermatome and the fact that a given spinal segment supplies a visceral area and a well delineated peripheral area. Of these foundations, he ingeniously mapped out the possible spinal segmental distribution of cutaneous nerves causing referred peripheral signs from near and distant visceral disturbances. He has shown that signs and symptoms originating in the heart are

generally referred to the spinal segments supplied by the third to the fifth cervical and the higher thoracic; but they may be also referred as low as the eighth thoracic. As for the abdominal viscera, Head states that referrals from the stomach occur from the seventh or eighth thoracic; referrals from the liver, the eighth to the tenth thoracic, and the gallbladder refers signs and symptoms to the areas supplied from the fifth to the ninth thoracic. (Fig. 1.)

Figure 1 illustrates the peripheral area (dotted) in which referrals can occur from the heart, gallbladder, stomach and liver. Again we see an overlapping of the nervous mechanism responsible for the severity and location of signs and symptoms in disease.

Ninety-two cases which were admitted to the Memorial Hospital, Albany, New York, were reviewed. These admissions occurred from January, 1942, to January, 1946; ninety-one of these cases had a final diagnosis of coronary thrombosis and one case had a diagnosis of ruptured aortic aneurysm. One selected case admitted to the Albany Hospital in 1945 was used for illustration but this case was not used in any calculations. The youngest patient was thirty-six years old and the oldest was eighty-four. There were seventy-three males and nineteen females. The overall mortality of the group was forty-nine or a mortality rate of 53.3 per cent. The greatest number of cases occurred in the age group fifty to fifty-nine, where there were thirty-eight or a percentage of 41.3 per cent of the total. The highest mortality rate with respect to age occurred in the age group eighty to eighty-nine but since only one case was reported in this decade and only five in the seventy to seventy-nine group, the most significant mortality rate can be said to have occurred between the ages of sixty to sixty-nine, where twenty-eight cases were reported and twenty-one died, producing a mortality rate of 75.0 per cent. The mortality rate for females was 63.2 per cent as compared to 50.7 per cent for the males.

Table 1 compares the cases as to their age groups and their mortality rates with re-

spect to age. Table II compares sex and the mortality rate in reference to sex.

A study of the cases for abdominal symptoms reveals some interesting data. The group was investigated in the following manner: those who had abdominal

TABLE I

Age.....	30-39	40-49	50-59	60-69	70-79	80-89
No. of cases.....	4	16	38	28	5	1
Per cent of cases...	4.35	17.39	41.30	30.435	5.435	1.09
Mortality.....	2	5	16	21	4	1
Mortality, per cent	50.00	31.25	42.11	75.00	80.00	100.00

TABLE II

Sex.....	Males	Females
Number.....	73	19
Per cent.....	19.35	20.65
Mortality.....	37	12
Mortality, per cent.....	50.68	63.16

TABLE III

Symptoms	No.	Per Cent	Mortality	Per Cent
Abdominal symptoms.....	20	21.74	14	70.00
Pain only.....	7	7.61	6	85.71
Nausea and vomiting only...	6	6.52	4	66.67
Pain, nausea and vomiting...	7	7.61	4	57.14
No other symptoms other than abdominal.....	11	11.96	8	72.73

symptoms, those whose abdominal symptoms consisted only of nausea and vomiting, those who had pain, nausea and vomiting and those whose abdominal symptoms were the sole symptoms of their disease; 21.8 per cent of the total cases studied had abdominal symptoms of which pain, nausea and vomiting occurred in about the same frequency. In 11.9 per cent of the group, abdominal symptoms comprised the only symptom of the patient's underlying condition. It is interesting to note that the mortality rate of the cases in which abdominal symptoms occurred was 70.0 per cent, which is well above the mortality rate of 53.3 per cent for the

entire series. Table III illustrates the above data.

#### CASE REPORTS

CASE 1. L. B., a fifty year old white male dairy farmer, was admitted to Memorial Hospital on January 12, 1946, with a chief complaint of acute pain in the mid-abdomen. One hour before admission, the patient was seized with a severe pain in the abdomen which was sudden in onset. The pain was accompanied with nausea and vomiting and observers reported that questionable hematemesis had occurred. The pain was located between the epigastric lower area and the umbilicus and was in the midline. The bowels did not move on the day of admission but were normal previously. The patient could not state whether or not tarry stools had occurred. The patient stated that he had been bothered for the past six months with "stomach trouble" but no positive history of heartburn, sour stomach or pain could be obtained.

The patient had not had any medical contact for twenty years previous. He claimed perfect health and had no shortness of breath or chest pain. (It was later determined that this patient had been rejected for employment one year previous because of high blood pressure.)

Physical examination revealed the temperature to be 98°F., the pulse 70, and the blood pressure 120/70. He was a stocky, middle-aged male in much distress, alert and conscious. Examination of the head revealed nothing abnormal. There was no percussion dullness in the chest, breath sounds were normal and no râles were heard. The heart was not enlarged to percussion; its rhythm and rate were regular. There was a soft systolic murmur at the apex not well transmitted.

The abdomen was obese and muscular rigidity could not be well determined, but no marked spasm was present. There was tenderness over the entire abdomen but it was most pronounced just above the umbilicus. Rectal examination revealed nothing unusual. Reflexes were elicited in the extremities.

The white blood count was 7,500 with the Schilling index slightly to the left. The urine was negative. Serum amylase was 75 dextrose equivalents. An electrocardiogram was not taken.

One hour after admission, the patient appeared somewhat better. The pain had lessened

and was localizing in the right upper quadrant. The pulse rose to 86 and the blood pressure rose to 140/80. A provisional diagnosis of gall-bladder colic was made. Four hours after admission, the pulse rose to 98 and the blood pressure was 150/60. The pain remained in the right upper quadrant, but the patient's general condition was much improved and he was allowed morphine gr.  $\frac{1}{6}$  and fluids. Shortly after this he complained of a tightness in his chest but this did not remain. Six hours after admission he suddenly became cyanotic and pulseless and expired while efforts were being made to institute oxygen.

Postmortem examination revealed a ruptured aneurysm of the ascending aorta, hemo-pericardium and cardiac tamponade. Examination of the abdomen revealed no pathological condition.

CASE 11. J. G., a thirty-four year old white male was admitted to Albany Hospital, February 25, 1945, with a chief complaint of agonizing pain in the epigastrium. Two hours before admission, this patient was seized with a severe pain in his upper abdomen. Twenty-four hours prior to admission, the patient had a mild pain in the left shoulder but was perfectly well until the chief complaint occurred. There was a history of mild nausea and vomiting just before and during the onset of the pain. There were no complaints of previous chest pain. The patient was known to have a peptic ulcer and had had several exacerbations recently.

Physical examination revealed the temperature to be 99°F., the pulse 90, and the blood pressure 80/40. Examination of the head revealed nothing abnormal. Respirations were increased, but no râles were heard in the chest. The heart sounds were of good quality and the rhythm and rate were regular. There was a generalized spasm of the abdomen including both quadrants. The epigastric region was extremely tender to palpation.

The white blood count was 22,500 cells and the urine was negative. The electrocardiogram showed some myocardial damage to the posterior wall. X-ray of the abdomen for free air was negative.

Two hours after admission, the temperature rose to 100°F. and the white blood count rose to 35,000. The abdomen remained markedly spastic throughout, and the blood pressure and pulse remained unchanged. After a thorough medical and surgical consultation, a diagnosis of a ruptured ulcer was agreed upon because of the marked generalized abdominal rigidity,

agonizing abdominal pain, markedly elevated and rising white blood count and rising temperature. An exploratory laparotomy was performed but no abdominal condition was found to explain the physical signs. On the first post-operative day, the patient's condition remained the same. The second day the temperature rose to 103°F. but the patient appeared somewhat improved. The blood pressure had risen to 90/65 and the breathing was not labored. Late that night, however, the patient suddenly had great difficulty in breathing, became cyanotic and expired.

Postmortem examination revealed a thrombosis of the right coronary artery, rupture of the posterior wall of the left ventricle, hemo-pericardium and a benign, duodenal, peptic ulcer.

#### DIAGNOSTIC AIDS

All agencies should be used in the differential diagnosis of an acute condition of the heart and abdomen. There is no single sign or test which can accurately place the disorder; rather a total evaluation of the avenues of information must be employed.

In some cases the patient is so moribund that an adequate history is not available. However, in those instances in which a history can be taken, a careful review should be made as to whether previous attacks of chest pain have occurred, whether there has been preceding shortness of breath, whether there have been attacks of heartburn, gas or abdominal distress associated with eating, and whether there have been tarry stools.

In the physical examination, aid can be given to differentiation. There has been too severe a stress laid on the rise in pulse rate in acute abdominal disorders. Unless hemorrhage occurs, there is usually little alteration in the pulse. Wagensteen<sup>8</sup> states, "even such a tragic occurrence as an acute perforation of a duodenal ulcer is not accompanied by material quickening of the pulse." This has been the writer's experience. Of course, later in an abdominal disorder, the behavior of the pulse is governed by changes and demands on the general body economy. In acute conditions of the heart, the pulse is more apt to

change, either in rate or in quality, often in both of these.

These same observations may be made for blood pressure. Substantial drops in arterial pressure are not usually seen in the early acute condition of the abdomen unless hemorrhage occurs. Later, when and if quickening of the pulse occurs, descending blood pressures may be recorded. A fall in the systolic pressure is much more apt to occur early in coronary occlusion, ruptured aneurysms, etc.

The electrocardiogram should always be utilized in diagnosis and the practice of postponing the electrocardiogram to include delayed changes in the tracing is to be condemned. The rate of appearance of pathological tracings is directly proportional to the rate of myocardial ischemia; and while changes in the electrocardiogram can take several days to develop, they can also appear in hours, minutes and even seconds.<sup>9</sup> Delay in obtaining an electrocardiographic record will postpone many early diagnoses of coronary occlusions; and since this procedure is harmless to the patient, it should be carried out immediately.

The white blood count is a dangerous index to employ but some conclusions can be cautiously drawn from it. A leukocytosis occurs in coronary thrombosis as well as in an acute condition of the abdomen but it can be generally said that the leukocytosis is seen earlier in the abdominal conditions and is apt to be higher in these states. The usual leukocyte rise in coronary thrombosis is between 10,000 to 15,000, but can be observed as high as 25,000.<sup>10</sup> Counts above this figure are not common. One feature of the white blood count which is significant, however, is a steady hourly rise in conjunction with the continuation of other abdominal symptoms. This very strongly points to abdominal disorders.

Fever is very similar to the white blood count in its significance. It can occur in both coronary and abdominal tragedies but its presence in coronary occlusion is generally restricted to rises of about 100°F. and the rise is usually later than in abdominal

emergencies. Again, a steady rise in temperature in the absence of chest complications is significant in the diagnosis of acute abdominal disorders.

The use of roentgenography is to be encouraged as a diagnostic confirmation. Although many acute abdominal conditions produce a negative x-ray, the presence of gas in the free peritoneal cavity is almost invariably a sign of leakage in the gastrointestinal canal and a diagnosis of a perforated viscus can rightfully be made from this finding. It should be emphasized, however, that failure of this sign never precludes a diagnosis of ruptured ulcer.

#### SUMMARY

1. A discussion of confusing symptomatology in acute abdominal and acute coronary pathological states has been made.
2. Possible pathways for transfer of these symptoms have been outlined.
3. A series of ninety-two unselected cases has been presented of which coronary occlusion comprised all but one case.
4. The overall incidence of abdominal symptoms in the series was 21.8 per cent and 11.9 per cent of the series had abdominal symptoms as the only symptom complex.
5. The differential aids in the diagnosis of the acute coronary and acute abdominal states were discussed.

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# USE OF CHEMOTHERAPY AS POSSIBLE MEANS OF REDUCING MORTALITY RATE IN PERFORATED PEPTIC ULCER\*

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DETROIT, MICHIGAN

THE mortality of 15 to 20 per cent attending the acute perforation of a peptic ulcer is so high and has been so consistent over a period of years that any means of reducing it should be welcome. Both in the records of the past twenty-five years which are accessible to us at Detroit Receiving Hospital, and those reviewed in the literature, the tendency towards a high death rate is unmistakable. Shawan<sup>1</sup> in 1937, reviewed the cases of perforated ulcer which had been treated at Detroit Receiving Hospital, from January, 1920, to January, 1937 and found that the operative mortality was 25.8 per cent. The authors carrying this study up to January 1, 1945, learned that the average operative mortality for the last eight years was 17 per cent. These results are in agreement with those reported from other institutions. In 1934, Eliason and Ebeling<sup>2</sup> collected 5,061 cases which had been recorded in the literature since 1921 and found that the average operative mortality was 23.9 per cent. Since this series apparently included only those patients who were subjected to operation and not those who for a variety of reasons did not come to operation, the actual death rate for perforated ulcers during this period was undoubtedly higher. DeBaKey<sup>3</sup> published an extensive review of the literature in 1940. He found that the total general mortality for a collected series of 16,752 cases reported in the previous decade was 25.2 per cent, while the operative mortality for a similar collected series of 15,340 cases was 23.4 per cent. He

observed further that the mortality had not decreased appreciably during the ten-year period from 1930 to 1939. The mortality of a collected series of 2,140 cases which were reported in 1930 was 26.1 per cent and that for 2,476 cases reported in 1939 was 23.7 per cent. While in general these figures can be accepted as indicative of the approximate mortality for the year in which they were reported, they are subject to some error as the year in which a series of cases is reported is usually not the year in which the cases were treated. Since most published series encompass a period of ten to twenty years, a more accurate estimate of the current mortality can be obtained if the figures are arranged to include only those cases which have been treated recently. In Table 1 are listed the cases which have been treated in the last fifteen years and have been reported in the English literature since 1939. The gross mortality for this group of 6,240 cases, which includes both operated and non-operated cases, was 19 per cent, while the operative mortality for 2,231 similar cases was 17.4 per cent.

The mortality trend can be determined more satisfactorily if the figures from one institution or from one geographical area are followed over a period of years. Such information is available for the Massachusetts General Hospital from 1896 to 1940 in the papers of Richardson<sup>26</sup> and Ulfelder and Allen<sup>19</sup> (Table 11), and for an area in the West of Scotland in the paper

\* From the Department of Surgery, Wayne University College of Medicine and the Division of Surgery, City of Detroit Receiving Hospital. Paper presented before the Society of University Surgeons' Annual Meeting February 7, 8 and 9, 1946.

of Illingsworth Scott and Jamieson.<sup>24</sup> (Table III).

These figures fail to show any substantial decrease in the mortality of this disease during recent years. The experience at the Detroit Receiving Hospital which is given

rule, and it must be admitted that the current operative mortality is in most instances between 15 and 20 per cent, and that the over-all death rate is about 20 per cent. It is true that these results can be improved by early operation, but this is

TABLE I

GROSS AND OPERATIVE MORTALITY FOR CASES OF PERFORATED PEPTIC ULCER, TREATED SINCE 1929 AND REPORTED IN THE ENGLISH LITERATURE SINCE 1939

Author	Period	Total Cases	Total Deaths	Gross Mortality, Per Cent	No. Patients Operated	No. Operative Deaths	Operative Mortality, Per Cent
Ross <sup>4</sup> .....	1939-40	....	....	....	175	28	16.0
Henry <sup>5</sup> .....	1938-42	....	....	....	179	24	13.4
Cohn <sup>6</sup> .....	1935-40	....	....	....	300	45	15.0
Berson <sup>7</sup> .....	1930-40	75	10	13.3			
Timoney <sup>8</sup> .....	1935-43	....	....	....	246	48	19.5
Martz-Foote <sup>9</sup> .....	1931-37	....	....	....	50	13	26.0
Sangster <sup>10</sup> .....	1935-39	....	....	....	100	24	24.0
McClure <sup>11</sup> .....	1930-39	....	....	....	91	7	7.7
Fobes <sup>12</sup> .....	1940-41	....	....	....	8	1	14.2
Griswold, Antoncic <sup>13</sup> .....	1931-40	111	24	23.4	102	20	19.6
McCabe, Mersheimer <sup>14</sup> .....	1930-41	80	24	26.9	87	22	25.2
Eliason, Stevens <sup>15</sup> .....	1935-44	....	....	....	17	2	11.7
Straus <sup>16</sup> .....	1939-43	....	....	....	12	3	25.0
Donald, Barkett <sup>17</sup> .....	1936-40	124	31	25.0	116	23	19.8
O'Donoghue, Jacobs <sup>18</sup> .....	1930-39	....	....	....	200	49	24.5
Ulfelder, Allen <sup>19</sup> .....	1931-40	165	44	26.6			
Raw <sup>20</sup> .....	1939-44	....	....	....	312	45	14.4
Jackson, Metheny <sup>21</sup> .....	1941-43	30	8	27.0	24	2	8.0
Barber, Madden <sup>22</sup> .....	1937-42	....	....	....	86	11	12.8
Nisbet <sup>23</sup> .....	1932-40	....	....	....	33	10	30.3
Illingsworth, Scott, Jamieson <sup>24</sup> .....	1930-43	5550	1044	18.1			
Black, Blackford <sup>25</sup> .....	1935-45	96	14	14.6	93	11	11.8
Total.....	.....	6240	1199	19.0	2231	388	17.4

in Table IV is quite similar although there is a decrease in the mortality for the period of January, 1937 to 1945, compared to the period from January, 1920 to January, 1937. This may be explained in part by the fact that Shawan did not include in the first series any cases in which at operation the perforation was found to have sealed itself spontaneously, whereas all cases of acute perforation are included in the later series.

There are in the literature a few reports, such as those of McClure,<sup>11</sup> Graham<sup>27, 28</sup> and Berson<sup>7</sup> which show a marked fall in mortality rate during recent years. This, however, is the exception rather than the

not the entire solution, because first, there will probably always be patients who will not consult a physician promptly; and second, the current mortality is still 9.6 per cent (Table V) for all patients operated within eight hours of perforation. This can be compared with the figures of Eliason and Ebeling<sup>2</sup> who in 1934, found in a collected series of 319 cases that the mortality for those operated within six hours of perforation was 7.5 per cent, while for those operated between six and twelve hours it was 23.9 per cent.

If any significant progress is to be made toward lowering the death rate, it can be accomplished only by combatting bacterial

infection which is the chief cause of death. A review of sixty-five patients who died following operation for perforated peptic ulcer at the Detroit Receiving Hospital between January 1, 1937, and January 1,

directly to infection, either intraperitoneal or pulmonary (Tables vi and vii.) Of the patients whose deaths were the result of infection, eighteen had peritonitis or intraperitoneal abscess, six had pulmonary

TABLE II  
THE GROSS MORTALITY FOR PERFORATED PEPTIC ULCER  
AT THE MASSACHUSETTS GENERAL HOSPITAL FROM  
1896 TO 1940, AS PUBLISHED BY RICHARDSON<sup>26</sup>  
AND ULFELDER AND ALLEN<sup>19</sup>

Period	Total Cases	Total Deaths	Mortality, Per Cent
1896-1900	6	5	83.0
1901-1905	12	7	58.0
1906-1910	33	11	33.0
1911-1915	31	9	29.0
1916-1920	36	11	30.6
1921-1925	43	11	25.6
1926-1930	90	24	26.7
1931-1935	74	20	26.5
1936-1940	91	24	26.4

TABLE III  
THE GROSS MORTALITY OF PERFORATED PEPTIC ULCER  
IN THE WEST OF SCOTLAND FROM 1924-1943, AS  
PUBLISHED BY ILLINGSWORTH, SCOTT AND  
JAMIESON<sup>24</sup>

Year	No. Cases	Recovered	Died	Mortality, Per Cent
1924	191	142	49	25.7
1925	205	160	45	22.0
1926	274	203	71	25.9
1927	283	222	61	21.6
1928	318	258	60	18.9
1929	335	269	66	19.7
1930	311	240	71	22.8
1931	328	265	63	19.3
1932	336	284	52	15.5
1933	317	247	70	22.1
1934	395	312	83	21.0
1935	378	312	66	17.5
1936	373	302	71	19.0
1937	374	293	81	21.7
1938	431	338	93	21.6
1939	432	357	75	17.4
1940	518	425	93	18.0
1941	615	502	113	18.4
1942	366	306	60	16.4
1943	376	323	53	14.1
Totals	5550	4506	1044	18.8

TABLE IV  
THE GROSS AND OPERATIVE MORTALITY OF PERFORATED  
PEPTIC ULCER AT THE DETROIT RECEIVING HOSPITAL  
FROM JANUARY, 1920, TO JANUARY, 1945

Period	Total Cases	Total Deaths	Mortality, Per Cent	No. Cases Operated	No. Operative Deaths	Operative Mortality, Per Cent
1920-37	Un-known	Un-known	Un-known	356	92	25.8
1937-38	36	12	33.3	33	9	27.0
1938-39	55	15	27.3	49	12	24.5
1939-40	55	15	27.3	46	7	13.0
1940-41	51	10	19.6	49	8	16.3
1941-42	53	8	15.1	52	7	14.0
1942-43	62	8	12.9	59	5	8.7
1943-44	46	10	21.7	45	9	19.0
1944-45	49	8	16.3	49	8	16.3
Totals	407	86	21.1	382	65	17.01

infection and seventeen had a combination of both intraperitoneal and pulmonary infection. There were, in addition to the forty-one patients cited above, 10 or 15 per cent in whom infection appeared to be an important contributory cause of death. Thus, there were only fourteen deaths (21 per cent) which occurred without evidence of bacterial infection.

The figures in Table vi and vii agree quite well with those reported by other authors. Table viii shows the figures for several series of collected cases and Table ix gives the causes of death in a collected series of patients reported in the English literature since 1939, who had been operated on during the last fifteen years and for whom the cause of death was accurately recorded.

It is fairly clear from the evidence cited above, that infection, primarily intraperitoneal, but also pulmonary, is the greatest factor which must be dealt with if the death rate from perforated peptic

1945, revealed that of the sixty-five deaths, forty-one or 65 per cent, can be attributed



ulcer is to be lowered. Before discussing the possibility of accomplishing this, it is important to dispel the often quoted statement that the peritoneal exudate is sterile during the early hours subsequent to perforation of a peptic ulcer. A number

toneal fluid, bacteria were recovered in only 65 per cent of the cases but when 3 cc. of exudate was used for the culture, the incidence of positive samples was increased to 81 per cent. Dudgeon and Sargent<sup>38</sup> were able to recover bacteria from only four of

TABLE V  
THE OPERATIVE MORTALITY FOR CASES OF PERFORATED PEPTIC ULCER TREATED WITHIN THE LAST FIFTEEN YEARS WHICH WERE OPERATED WITHIN EIGHT HOURS AFTER PERFORATION, AND WHICH WERE REPORTED IN THE ENGLISH LITERATURE SINCE 1939

Author	Period	Interval between Perforation and Operation in Hours	No. of Cases	No. of Deaths	Mortality, Per Cent
Martz, Foote <sup>9</sup> .....	1931-37	6	29	5	17.0
Griswold, Antoncie <sup>13</sup> .....	1931-40	6	44	2	4.0
O'Donoghue, Jacobs <sup>18</sup> .....	1930-39	6	27	3	11.0
Raw <sup>20</sup> .....	1939-44	6	139	9	6.5
Jackson, Metheny <sup>21</sup> .....	1941-43	8	15	0	
Barber, Madden <sup>22</sup> .....	1937-42	6	35	0	
Nisbet <sup>23</sup> .....	1932-40	8	14	2	14.0
Black, Blackford <sup>25</sup> .....	1935-45	6	46	5	11.0
Illingsworth, Scott, Jamieson <sup>24</sup> .....	1938-43	8	651	71	10.9
Totals.....	.....	..	954	92	9.6

of authors, among whom are Ross,<sup>4</sup> Urrutia,<sup>29</sup> Ulrich,<sup>30</sup> Brenner,<sup>32</sup> Gibson,<sup>33</sup> Loehr<sup>34</sup> and Deaver and Pfieffer<sup>35</sup> maintain that the peritoneal exudate is sterile for from six to twelve hours. On the contrary, Judine<sup>36</sup> and Bruett<sup>37</sup> found according to DeBakey<sup>3</sup> a high incidence of positive cultures in their cases. Other reports in the literature indicate that bacteria may be recovered from the peritoneal exudate with considerable frequency. In a collected series of 716 cases, bacteria were recovered from 279 or 38.9 per cent. (Table x.) Only three of the authors<sup>3,40,49</sup> whose results are listed in Table x describe the method they employed in making the culture. If as is probably the case, these cultures were obtained by collecting a swab of peritoneal exudate upon opening the peritoneum and only aerobic incubation was employed, it can be safely assumed that the incidence of bacteria in the peritoneal exudate was definitely higher than that given in most of the reports. Henry<sup>3</sup> learned that if swabs were employed to collect samples of peri-

seven peritoneal fluids, but material obtained from the edge of the ulcer was positive in all seven instances. Since bacteria are probably not uniformly distributed in the material which escapes from the perforation, it is proper to assume that they will not be uniformly distributed in the peritoneal cavity unless there is a considerable amount of fluid present. Conceivably, a piece of contaminated food might lodge under the diaphragm and yet the free peritoneal cavity contain exudate that is relatively sterile. The results seem to indicate that the incidence of positive cultures would increase in direct proportion to the care employed in collecting and incubating the material. The frequency of wound infection and wound disruption lends support to the contention that the peritoneal fluid contains bacteria. DeBakey<sup>3</sup> found that 196 or 25.4 per cent of 772 collected cases had wound infection or wound disruption. The incidence of wound infection in 635 patients who have been operated upon since 1929 and published



TABLE VI  
CAUSE OF DEATH IN SIXTY-FIVE OPERATIVE CASES OF PERFORATED PEPTIC ULCER, SEEN AT DETROIT  
RECEIVING HOSPITAL

Hospital Number	Culture of Peritoneal Fluid at Operation	Cause of Death	Interval between Perforation and Operation	Interval between Operation and Death
S-719	.....	Postoperative lobar pneumonia	4 hr.	4 days
S-6384	.....	Unknown. Had received mercury for lues	16 hr.	12 hr.
S-8524*	.....	Postoperative pneumonia evisceration. Subdiaphragmatic abscess. Gastroplular fistula. Lung abscess. Localized peritonitis	14 hr.	2½ mo.
S-10100*	.....	Generalized peritonitis. Postoperative atelectasis. Pulmonary congestion	10 hr.	32 hr.
S-10634	.....	Eviscerated 9th day. Died of pneumonia 11th day	5 hr.	11th day
S-12628*	Streptococci. Staphylococci. B. coli	Gangrenous duodenum. Subdiaphragmatic abscesses. Tuberculous peritonitis	7 days	12th day
S-14100*	.....	Generalized peritonitis	48 hr.	2nd day
S-20438	.....	Pneumonia	3 hr.	2nd day
S-17176*	.....	Subhepatic abscess. Duodenal fistula	10 days	21st day
T-162*	.....	Coronary arteriosclerosis. Cardiac hypertrophy	4½ hr.	10th day
T-1901*	.....	Generalized peritonitis	23 hr.	5th day
T-2272*	.....	Evisceration 8th day. Pelvic abscess. Cerebellar malacia. Cardiac failure	5 hr.	19th day
T-2502*	.....	Peritonitis	5½ hr.	3rd day
T-2731*	Non-hemolytic streptococci	Peritonitis	23 hr.	11th day
T-3395*	.....	Peritonitis and pelvic abscess	12½ hr.	7th day
T-4350	.....	Peritonitis	3½ hr.	7th day
T-5089*	.....	Peritonitis. Acute cardiac failure	9½ hr.	24 hr.
T-8649	.....	Cause unknown	24 hr.	6th day
T-10027*	.....	Lobar pneumonia	11½ hr.	24th day
T-10726*	.....	Peritonitis. Early lobar pneumonia	4½ hr.	5th day
T-17736	.....	Malnutrition and anemia. Jejunostomy done after pyloric obstruction	8 hr.	2 mo.
V-1146*	Streptococcus viridans	Peritonitis	8 hr.	45 hr.
V-9732*	Staphylococcus albus	Peritonitis. Pneumonia	9¾ hr.	2½ days
V-13225*	B. coli, B. cloacae, B. proteus, streptococcus overgrown by Proteus	Pneumonia. Peritonitis	8½ hr.	6th day
V-14255*	B. coli. Staphylococcus albus	Subhepatic abscess. Pneumonia	6 hr.	6th day
V-18818*	Pneumococci Type 29. B. coli. Staphylococcus albus. Non-hemolytic Streptococci	Peritonitis. Lobar pneumonia	12 hr.	13th day
V-2748*	Streptococcus viridans. B. lactis aerogenes	Peritonitis. Bronchopneumonia	7½ hr.	9 days
V-12415*	Aerobic and anaerobic streptococci. B. Proteus	Subdiaphragmatic abscess extension and ulcer of the chest wall	5½ hr.	5 mo.
X-155*	B. alkaligenes, B. coli. Staphylococcus albus†	Subdiaphragmatic abscess. Pneumonia	21 hr.	12th day
X-2859	Non-hemolytic streptococci. B. coli. B. cloacae	Peritonitis	27 hr.	30 hr.

TABLE VI (Continued)

Hospital Number	Culture of Peritoneal Fluid at Operation	Cause of Death	Interval between Perforation and Operation	Interval between Operation and Death
X-9232*	Streptococcus viridans	Subdiaphragmatic abscess. Empyema	4¾ hr.	7th day
X-11381*	Non-hemolytic streptococci. B. coli	Pneumonia. Abdominal abscess. Ca of lung, prostate and pituitary	12 hr.	3rd day
X-11698*	Autopsy cultures. Non-hemolytic streptococci. B. coli. B. lactis aerogenes	Lobular pneumonia. Peritonitis	24 hr.	5th day
X-17616	Non-hemolytic streptococci	Peritonitis	24 hr.	17 hr.
X-18642	Streptococcus viridans	Pneumonia Type 24. Peritonitis	11¾ hr.	15th day
X-13983*	Streptococcus viridans. Spore bearers	Left subdiaphragmatic abscess. Multiple lung abscesses	14 hr.	1½ mo.
41-466*	No growth	Lobar pneumonia, pneumococcus Type 2	3¾ hr.	7th day
41-3100*	Non-hemolytic streptococcus	Pneumonia. Peritonitis. Streptococcus septicemia	7 hr.	8th day
41-12562	Streptococcus viridans. B. coli	Cause unknown. Believe to have multiple sclerosis	8 hr.	15th day
41-13512	No growth	Peritonitis	9½ hr.	5th day
41-14414	B. coli. Non-hemolytic streptococci	Pneumonia	4¼ hr.	2nd day
41-2742	Streptococcus viridans. Hemolytic streptococci	Intestinal obstruction. Empyema	3¾ hr.	2 mo.
41-17886	Non-hemolytic streptococci	Peritonitis	3 days	11th day
42-650	.....	Shock (sub-total gastric resection)	7½ hr.	11 hr.
42-4448*	B. coli. Yeasts	R.L.L. Pneumonia. Peritonitis	12 hr.	2nd day
42-8508	No growth	Unknown	5½ hr.	9th day
42-1739*	Streptococcus viridans	Pneumonia. Massive pulmonary embolus	12 hr.	6th day
42-9654*	No growth	Peritonitis	30 hr.	2nd day
43-2570	.....	Cause unknown. Chronic alcoholic. Course progressively downhill	17 hr.	40th day
43-4387	.....	Peritonitis	14 hr.	19th day
43-4730*	.....	Pulmonary embolus	5 hr.	10th day
43-6100*	Non-hemolytic streptococci. Spore bearers	Peritonitis	9 hr.	8th day
43-8125	Staphylococcus albus. Streptococcus viridans	Pneumonia. Peritonitis	18½ hr.	4th day
43-6517*	B. coli. Spore bearers	Peritonitis	44 hr.	3rd day
43-7496	Streptococcus viridans. Staphylococcus albus	Peritonitis	10 hr.	4th day
43-7863	Staphylococcus albus. Hemolytic streptococcus	Peritonitis. Pleural effusion	48 hr.	31st day
43-10571	.....	Shock	17 hr.	6 hr.
44-158	B. coli. Spore bearers	Cause unknown	24 hr.	1 day
44-1372	Pneumococci. Type 13	Peritonitis	3 days	22nd day
44-5738*	Staphylococcus albus. Pneumococcus Type 13	Peritonitis. Pulmonary TBC	7 hr.	2nd day
44-7612	B. coli. Streptococcus viridans	Malnutrition. Patient became psychotic	8 hr.	15th day
44-11825	Staphylococcus albus. Non-hemolytic streptococcus	Gastric fistula	14 hr.	17th day
44-15687*	B. coli. Non-hemolytic streptococcus	Peritonitis. Volvulus intestinal obstruction	36 hr.	25th day
44-15936*	No growth	Lobular pneumonia	15 hr.	7th day
44-16099*	Pneumococcus	Peritonitis. Lobular pneumonia	18 hr.	3rd day

\* Autopsy.

† Autopsy culture.

in the English literature since DeBakey's review is 22.5 per cent. (Table XI.)

It therefore seems logical to assume that if infection could be controlled the mortality attending the perforation of a peptic ulcer would be lowered. A number of

TABLE VII  
(SUMMARY OF TABLE VI)

	No.	Per Cent
Number of deaths.....	65	
Patients dying of peritonitis.....	18	27.6
Patients dying of pulmonary complications.....	6	9.0
Patients dying of both peritonitis and pulmonary complications....	17	26.0
Patients in whom infection appeared to be an important contributory cause of death.....	10	15.0
Patients dying of other causes than infection.....	14	21.0

authors, among whom are Flemming,<sup>28</sup> Eliason and Stevens,<sup>15</sup> O'Donaghue and Jacobs,<sup>18</sup> Eliason and Ebeling,<sup>2</sup> McNealy and Howser,<sup>51</sup> Paletta and Hill,<sup>32</sup> Timoney,<sup>8</sup> Griswold and Antoncic,<sup>13</sup> Ulfelder and Allen,<sup>19</sup> have recognized this fact and several have suggested the use of sulfonamides.<sup>3, 15, 19, 52</sup> Conclusive evidence in support of the efficacy of the sulfonamides as a means of controlling infection has not yet been published, but it seems safe to predict that the death rate will not be reduced appreciably by such therapy since the sulfonamides in therapeutic concentrations are effective against only certain bacteria. Peritonitis in these cases may result from any organism capable of inhabiting the mouth, nose and pharynx or which may be present in food. Usually a variety of bacteria are present. It is likely, therefore, that the two antibiotic agents, penicillin and streptomycin, would be more effective than the sulfonamides because their combined range of antibacterial activity includes most of the organisms which cause infection in such patients. It is the author's contention that early and intensive treatment with these antibiotics would lower the mortality significantly.

Doses of 75,000 to 100,000 units of penicillin every two hours and 0.5 of a Gm. of streptomycin intramuscularly every six hours are not too large. Therapy should be started as soon as the diagnosis is established and continued until the tempera-

TABLE VIII  
CAUSES OF DEATH IN SEVERAL COLLECTED SERIES OF PERFORATED PEPTIC ULCER

Author	Year	No. of Deaths	Per Cent Due to Intra-peritoneal Infection	Per Cent Due to Pulmonary Complications	Total Per Cent Deaths Due to Infections
Flemming <sup>28</sup> .....	1931	253	69.9	13.0	82.9
Eliason and Ebeling <sup>2</sup> .....	1934	672	63.9	15.3	79.2
DeBakey <sup>2</sup> .....	1940	652	57.2	20.8	78.0

ture has been normal for several days or until it is evident that treatment is ineffective. In these cases one is usually dealing with an unknown mixture of bacteria, some of which may be quite resistant to penicillin or streptomycin, and it is essential to employ a dose which will provide a concentration high enough to inhibit fairly resistant organisms. The tendency to use small doses of penicillin stems from the fact that when penicillin was first available it was so scarce that small doses had to be employed. A number of therapeutic failures may have been due to an inadequate dose. It has recently been demonstrated in the treatment of subacute bacterial endocarditis that cases similar to those which formerly failed to respond to penicillin therapy can be cured if large enough doses are used.<sup>53</sup> Crile and Fulton<sup>54</sup> have presented evidence which seems to show that large doses of penicillin (100,000 units every two hours) are more effective in the treatment of peritonitis arising from inflammation of the appendix than the conventional smaller doses.

If penicillin and streptomycin are to be given a fair chance, the doses should be large and treatment should be started as soon as the diagnosis is made rather than at the close of the operation. All forms of chemotherapy are more effective during

the invasive phase of the infection than they are after the bacteria have become well established. Presumably it will be sufficient to administer the antibiotics systemically, since it has been shown<sup>55</sup> that streptomycin given intramuscularly

They point out that the restoration of a normal blood and interstitial fluid volume by the administration of whole blood, plasma and electrolyte solutions is of great importance.

Graham<sup>31</sup> in particular, on the basis of

TABLE IX  
CAUSE OF DEATH IN PATIENTS WHO WERE OPERATED ON FOR PERFORATION OF A PEPTIC ULCER IN THE LAST FIFTEEN YEARS, AS RECORDED IN THE ENGLISH LITERATURE SINCE 1939

Author	Period	No. of Deaths	Peritonitis		Pulmonary Infection		Peritonitis and Pulmonary Inf.		Other* Causes		Total Per Cent of Deaths Due to Infection
			Autopsy	No Autopsy	Aut.	No Aut.	Aut.	No Aut.	Aut.	No Aut.	
Martz, Foote <sup>9</sup> .....	1931-37	13	5	1	1	1	1	..	..	4	69.2
Timoney <sup>8</sup> .....	1935-43	14	3	2	0	6	0	0	..	3	78.5
McClure <sup>11</sup> .....	1930-39	7	0	3	0	1	0	0	..	3	57.1
Fobes <sup>12</sup> .....	1940-41	1	..	..	..	..	..	..	..	1	0.0
Griswold, Antoncie <sup>13</sup> .....	1931-40	20	0	10	0	0	0	6	0	4	80.0
Donald, Barkett <sup>17</sup> .....	1936-40	7	0	6	0	0	0	0	1	0	57.1
Jackson, Metheny <sup>21</sup> .....	1941-43	2	0	0	0	1	0	0	0	1	50.0
Nisbet <sup>23</sup> .....	1932-40	10	7	0	1	0	0	0	2	0	80.0
Black, Blackford <sup>25</sup> .....	1935-45	11	0	6	0	3	0	0	0	2	81.8
		85	15	28	2	12	1	6	3	18	

\* Death in some of the cases as listed in this column may have been due to infection either not recognized or other than pulmonary or intraperitoneal. For example, the cause of death for one of the cases in the group of Griswold and Antoncie is given as hemolytic streptococcus septicemia. Other authors have listed patients as dying of shock, which may have been due to fulminating peritonitis, or of duodenal fistula in the cause of which infection may have played a role.

or intravenously to such patients rapidly appears in the peritoneal exudate. While it has not been demonstrated that penicillin reacts in a like manner, it seems likely that it, too, will appear in the peritoneal fluid promptly after intramuscular or intravenous injection.

We do not wish to leave the impression that chemotherapy will make it possible to neglect other essential measures in the pre- and postoperative care of these patients. Both McClure<sup>11</sup> and Graham<sup>27,31</sup> who have obtained remarkably low death rates (7.7 per cent for ninety-one cases and 6.3 per cent for 111 cases, respectively) have emphasized the need for adequate preoperative preparation of the patient.

this experience, minimizes the bacterial infection as a cause of death and suggests that the mortality could be lowered by more carefully attention to the preoperative preparation of these patients. The necessity of restoring the blood and interstitial fluid volume to near normal is emphasized by the number of reports in the literature describing deaths from spinal anesthesia or from shock shortly after the operation. Although the importance of proper pre- and postoperative care should be stressed, the fact still remains that there is considerably evidence to show that bacterial infection, either intraperitoneal or pulmonary, is also a significant cause of death. It seems, therefore, that the lowest mortal-

ity rate would be obtained by combining chemotherapy with adequate preoperative preparation and careful postoperative care.

### SUMMARY

#### 1. The operative mortality attending

TABLE X  
THE INCIDENCE OF BACTERIA IN THE PERITONEAL FLUID  
OF PATIENTS WITH PERFORATED PEPTIC ULCER

Author	Year	No. of Cases	No. of Positive Cultures	Per Cent of Positive Cultures
Dudgeon, Sargent <sup>38</sup> .....	1905	7	4	57.1
Deaver <sup>39</sup> .....	1913	20	6	30.0
Dudgeon, Maybury <sup>40</sup> ....	1915	23	10	43.5
Walker <sup>41</sup> .....	1915	29	14	48.3
Alexander <sup>42</sup> .....	1917	13	3	23.1
Richardson <sup>26</sup> .....	1917	35	7	20.0
Deaver, Pfeiffer <sup>35</sup> .....	1921	34	11	32.4
Gibson <sup>43</sup> .....	1928	43	15	34.9
Mattingly <sup>44</sup> .....	1931	46	9	19.6
Brenner <sup>32</sup> .....	1935	21	0	0.0
Trout <sup>45</sup> .....	1935	21	0	0.0
Chang, Chi Cheng <sup>46</sup> ....	1937	31	13	41.9
Graham <sup>28</sup> .....	1937	30	10	33.3
McCreery <sup>47</sup> .....	1938	42	22	52.4
Fallis <sup>48</sup> .....	1938	36	12	33.3
Davison, Aries, Pelot <sup>49</sup> ...	1939	34	18	52.9
Martz, Foote <sup>9</sup> .....	1940	23	12	52.2
Griswold, Antoncic <sup>13</sup> ....	1941	65	31	47.7
Berson <sup>7</sup> .....	1942	31	10	32.3
Henry <sup>5</sup> .....	1942	48	39	81.3
Estes, Bennet <sup>50</sup> .....	1944	25	8	32.0
Graham, Tovee <sup>51</sup> .....	1945	59	25	42.4
Totals.....		716	279	38.9

acute perforation of peptic ulcer is in most instances between 15 and 20 per cent.

2. Approximately 80 per cent of the deaths are due to bacterial infection either intraperitoneal or pulmonary.

3. Most of the bacteria involved in these infections are susceptible to penicillin or streptomycin.

4. It is believed that early and intensive treatment with penicillin and streptomycin of all patients with perforated peptic ulcer would reduce the mortality rate of this disease.

5. Chemotherapy should be considered an aid in the treatment of such cases and should not be substituted for careful surgery, or adequate pre- and postoperative care.

TABLE XI  
THE INCIDENCE OF WOUND INFECTIONS IN PATIENTS  
WITH PERFORATED PEPTIC ULCER

Author	Year	No. of Cases	No. of Infections	Per Cent of Cases Infected
McClure <sup>11</sup> .....	1930-39	91	7	7.8
McCabe, Mersheimer <sup>14</sup> ...	1930-41	87	27	31.0
Martz, Foote <sup>9</sup> .....	1931-37	50	6	12.0
Griswold, Antoncic <sup>13</sup> ...	1931-40	84	28	33.3
Timoney <sup>8</sup> .....	1935-43	246	63	25.6
Black, Blackford <sup>25</sup> .....	1935-45	93	10	10.8
Fobes <sup>12</sup> .....	1940-41	8	2	25.0
Totals.....		659	143	21.7

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# ANOMALOUS TALOCALCANEAL ARTICULATION

## CAUSE FOR LIMITED SUBTALAR MOVEMENTS

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IN two recent patients with sprains of the ligaments of the ankle and in a third with a fresh simple fracture of the fifth metatarsal bone, we observed the presence of limitation of passive subtalar rotatory movements. On further study of these three patients we noted the presence of an unusual anomaly of the talus and calcaneus. This abnormality which consisted of a bilateral symmetrical projection of bone on the medial surface of the talus and calcaneus, respectively, formed an accessory talocalcaneal articulation.<sup>1</sup> Since limitation of subtalar movements was present bilaterally, the conclusion was that the anomaly and not the recent trauma was the basis for the limited subtalar movement.

This paper is presented first, to emphasize the point that anomalous bony protuberances in the talocalcaneal region may result in limitation of subtalar movements and secondly, that these bony masses can be detected by radiographic examinations made in special oblique views of the feet.

### HISTORY AND PHYSICAL EXAMINATION

A review of the three patients in question showed that each suffered from a recent trauma to the ankle or foot. The diagnosis in the first was a simple fracture of the base of the fifth metatarsal bone, and in the other two, severe sprain of the ligaments of the ankle joint. Examination revealed, in addition to the local swelling and pain caused by the trauma, an enlargement on the medial aspect of the foot which was most prominent just below and slightly posterior to the inner malleolus. A smaller but similar type of prominence was encountered on the opposite foot of each of the three patients. In one of the three patients the protuberance on one foot was the size of a large cherry and was markedly tender to touch. On further questioning, this patient stated that he frequently wore low quarter shoes because of these painful

bony masses. The striking finding on examination of these three patients was the limitation from 5 to 15 degrees in the range of passive subtalar movements as compared to normal.

Radiographs taken in the conventional anteroposterior and lateral views did not clearly disclose the abnormality in the tarsal bones. When, however, examination of the talus was made in an oblique view, i.e., the leg in an externally rotated attitude from 10 to 25 degrees, one observed apposing beaks of bone projecting from the posteromedial aspects of the talus and calcaneus, respectively. In addition, a joint space was seen in anomalous talar and calcaneal protuberances. In one of the three patients who presented the largest abnormal bony projection in the group, the subchondral regions of one of the accessory talocalcaneal articulations were irregular in outline. (Fig. 1.)

Ordinarily no special treatment except the wearing of low quarter shoes is advised; however, the one patient in whom the bony projection was extremely large requested that something be done which would permit him to wear regular "G. I." shoes. Operative intervention was performed to expose the medial surface of the subtalar region of one foot. Twin beaks of bone which projected from the posterior portion of the medial surfaces of the talus and calcaneus, respectively, were clearly visualized as was the anomalous joint space. Each promonotory was only partly resected in order to retain the bony canal for the passage of the flexor hallucis longus tendon. (Fig. 2.) No operation was performed on the opposite foot.

The follow-up examination of this patient for a period of twelve months after the operation revealed that he was able to wear "G. I." shoes and had experienced only occasional local discomfort. Radiographic examination made, at intervals of

three months during this one year follow-up, showed no reformation of bone at the site of resection. There was no apparent increase in the range of subtalar movements after the operative intervention. The subtalar region on the medial aspect of the operated foot was normal in appearance and was not tender to firm local pressure or percussion.

The other two patients who did not require any surgical intervention received permission to wear low quarter shoes and apparently had no further complaints.

The examination of the tissue removed at the time of operation showed that the articular surfaces of the bony projections removed from the talus and calcaneus were dull, pitted and covered with fibrocartilage. The microscopic examination confirmed these findings as well as the existence of fibrosis of the subchondral marrow spaces. This pointed to an existence of a degenerative osteoarthritis of the anomalous talocalcaneal articulation.

#### COMMENTS

Whenever subtalar movements are restricted, either in association with flat feet or after a fresh trauma to the ankle or foot, it is suggested that oblique views be taken to the subtalar region in order to visualize the medial surfaces of the posterior half of the talus and calcaneus. In medicolegal cases it is important to check for this anomaly especially when restriction of subtalar movements is encountered after local trauma.

As for the basis of this anomaly, it is believed that an accessory island of bone in the region of the sustentaculum tali (os sustentaculi) fused with the calcaneus to form the bony promontory. Similar changes probably had occurred on the medial aspect of the talus. Apparently these anomalous bony projections interfere with the passive rotation of the calcaneus.

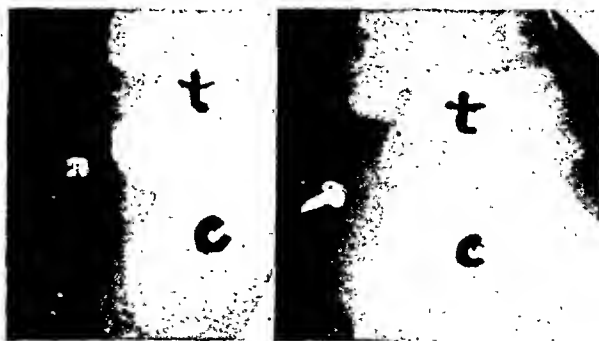


FIG. 1.

FIG. 2.

FIG. 1. Radiographic examination made in the oblique view shows symmetrical bony projections from the postero-medial aspects of the talus and calcaneus. Similar but smaller projections were present in the opposite foot; "t" is the talus and "c" is the calcaneus.

FIG. 2. Note the resected bony projections of the talocalcaneal articulation.

#### CONCLUSION

In three patients who suffered from recent trauma to the ankle or foot, we observed an anomalous bony projection from the medial surfaces of the talus and calcaneus, respectively. These bony prominences formed an accessory articulation and interfered with the normal range of passive movements of the calcaneus. Thus, the limitation of motion found in these patients was not the result of recent trauma but directly related to the anomalies of the feet. Only by making radiographic examinations in oblique views of the talus can these abnormal bony projections be clearly visualized. When these projections are unusually painful, large and interfere with the wearing of shoes as was noted in one case, resection is necessary; otherwise, the wearing of low quarter shoes is indicated.

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# SYMPATHETIC NERVE BLOCK IN HYPERTENSION AND ALLIED CASES

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SINCE 1939 we have been interested in the therapeutic uses of nerve block with alcohol. In the beginning our work was limited to intractable cardiac-asthma cases. However, for the past four years, we have performed alcohol blocks for hypertension and have arrived at some definite conclusions as to the results to be expected and the technic to be used. The advantage in this method over resection by surgery is its simplicity of performance and its less traumatizing effect on the patient.

The ganglion block for hypertension is done in two stages. Upon admission, the patient has a complete workup including an electrocardiograph, chest x-ray, Fishberg urine concentration test, urea nitrogen and creatinine determination, an eye ground examination and a series of blood pressure recordings. This series consists of five-minute lying, sitting and standing blood pressures and each of these is followed by another reading after the patient has had his hand immersed in ice water. When the necessary information is obtained the patient is then scheduled for the first stage. A preliminary hypodermic of morphine sulfate gr.  $\frac{1}{6}$  and scopolamine hydrobromide gr.  $\frac{1}{200}$  is given one hour before the operation. Cyclopropane is the preferred anesthesia.

Equipment needed for the procedure consists of:

## Sterile

- 6 long spinal needles
- 2 medicine glasses
- 1 five cc. syringe
- 4 towels
- Cotton balls and wipes
- Gloves

## Unsterile

- China glass pencil
- 2 Ace bandages
- Scultetus binder
- Blood pressure machine
- Stethoscope

## Solutions

- Absolute alcohol
- Tincture of merthiolate
- Novocaine 1%

Before and after the induction of anesthesia, the patient's blood pressure is taken and the cuff is then left on throughout the entire procedure. As soon as the patient is anesthetized, he is placed prone on the table with the arms outstretched and the toes extended just beyond the end of the table so that the legs are straight. The entire back from the neck to the coccyx is exposed. All points for injection are mapped out with the china glass pencil. A line is drawn along the spinous processes to include the eighth to twelfth thoracic and first lumbar vertebrae. Then at each spinous interspace a line is drawn perpendicularly to the vertical line. On the side to be injected at this time, another line is drawn parallel with the spinous process line and 4 cm. away from it. Where this line crosses each horizontal line, the sites for injection are located.

Each spinal needle is then inserted so that it impinges upon the transverse process. It is then withdrawn slightly and with a downward and inward tilt it is passed beneath the transverse process for a distance of approximately 1 cm. All of the six needles are thus placed into the sites of the eighth to twelfth thoracic and first lumbar ganglia. Five cc. of 1 per cent

novocaine is then injected into the first lumbar needle and that needle is withdrawn, leaving five needles *in situ*. Thereafter, 4 cc. of absolute alcohol is injected into each of the remaining needles. As soon as the absolute alcohol is injected

previously encountered before doing this. The novocaine acts as a pool in which the alcohol diffuses and becomes harmless.

The blood pressure is taken immediately upon the completion of the procedure and every few minutes thereafter until the

Case.....	G. M. 10/3/43 61 yr. Female	R. P. 11/10/43 28 yr. Male	J. C. 4/44/44 66 yr. Male	W. P. 5/31/44 29 yr. Male
Classification*.....	11	111	11 plus Asthma	
Blood pressure: pre-op..... post-op.....	270/160 160/100	210/140 170/100	195/135 140/80	190/10 140/70
Urine.....	negative albumin casts concentration—fair	albumin—trace sugar—trace concentration—fair	albumin—trace	negative
Eye grounds.....	moderate arteriosclerosis	silver-wire thin arteries left palpebral fissure enlarged	arteriosclerotic changes	negative
Heart.....	enlarged	left ventricular hypertrophy systolic murmur at apex not transmitted	marked enlargement verge of congestive failure	aortic insufficiency following Rheumatic Fever
Symptoms.....	persistent vertigo	blurred vision headaches head pressure and fullness chest tightness	Asthma—25 yr. bed-ridden intermittently for four years headaches vertigo chest tightness expectoration—cupful daily	hammer pulse head pounding chest tightness vertigo
Remarks.....	now symptom-free no medications	thoracic 8-9 were not done in this early case advised to return for this block, but declines because he is symptom-free	thoracic 1-4 bilateral no asthma since expectoration—negligible no cardiac stimulants symptom-free	left side only done immediately symptom-free and has remained so

\* As classified by Smithwick.

the needle is withdrawn. Aspiration before injecting any solution assures that the needle is not through the pleura or in any vessel. If blood or air is obtained replace that needle before injecting the solution.

The injection of the novocaine into the lumbar site prevents the alcohol from running down the plane in front of the vertebrae into a lower site and causing a paralysis. It also prevents a sciatic neuritis

drop has become stationary. Oxygen should be started as soon as the procedure is completed to assist the patient to react more quickly from the anesthetic and to prevent hypotension shock. The patient is kept prone until completely reacted and only then is turning permitted. Lying prone produces abdominal pressure which prevents any severe drop in the blood pressure. In order to maintain abdominal

pressure after the patient is turned, an abdominal binder may be applied.

As soon as the patient has reacted, he is returned to his bed and is encouraged to drink some hot fluids such as tea, coffee or broth. Careful check on the blood pressure is maintained and if at any time the systolic pressure drops to 100 or below, or if dyspnea occurs, oxygen is administered by mask and ace bandages are applied to the legs and the abdominal binder is tightened.

The second stage or the other side is done from five to seven days after the first stage. In the interval the patient is on a regular diet and is allowed out of bed as soon as able. Usually this is on the second or third day. The results have been more satisfactory when the left side is blocked first. The operative method and post-operative care is exactly the same for the second stage.

We have found another advantage in this type of procedure in that it widens the scope of its feasibility. Treatment of advanced cases has been attempted and in spite of their classifications which would have precluded surgery, several of these early cases are still alive after three years and are comparatively symptom-free.

The summary shown in the table on page 67 includes cases which have been chosen for their wide diversification of symptoms and length of time following surgery.

The following is an example of an advanced case done more recently:

A female, age fifty years, presented the following symptoms: persistent headaches, blurred vision, vertigo, inability to walk without staggering, nausea, primarily bed-ridden for four months.

Retinal changes showed marked AV compression; the vessels had a full copper wire

appearance in right disc and left retina had a large hemorrhage below disc at about five o'clock. Blood pressure was fixed at 230/130 to 270/150. The heart was enlarged with congestive heart failure at times. An electrocardiograph showed left ventricular hypertrophy and myocardial damage. Urinalysis showed concentration fair with a trace of albumin.

A bilateral thoracic eighth to twelfth was done in stages and the patient was discharged with a blood pressure of 190/110 and all symptoms gone except for blurred vision which was due to the hemorrhage.

She was seen after two months, having some cardiac distress but no head pounding and was otherwise still symptom-free. The eye grounds were markedly improved. The left thoracic third was blocked as an out-patient and after two weeks the heart was much improved and stronger; blood pressure now was 170/100.

Contrary to what was anticipated in the beginning that this procedure might be only a temporary relief, it has proven to be permanent. The symptoms of headache, headpressure, dizziness and vomiting are quickly corrected and our earliest patients are not only still symptom-free but also maintaining lower blood pressures. We are convinced that this is a much simpler and less drastic method than the sympathetic nerve and ganglion destruction by operative procedure as recognized throughout the world today.

Experimental work is now being done in combining thoracic one, two, three and four in separate stages to improve the heart action along with dropping the blood pressure. It is this approach that may give some relief for the malignant type of hypertension which is yet non-curable.

In conclusion may it be said that we believe the alcohol nerve blocks as described in this article have a definite place in the armamentarium of today in hypertension and asthma.



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# Case Reports

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## ANTERIOR THORACIC ESOPHAGUS

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**F**ORTY newborn babies with esophageal atresia and tracheoesophageal fistula have been successfully treated at The Children's Hospital in Boston. Of this group, twenty-three have had successful end-to-end anastomosis of the esophagus.

Because primary anastomosis was deemed inadvisable, the remaining seventeen infants had multiple-stage procedures. The operations consisted of division of the tracheoesophageal fistula, gastrostomy, and marsupialization of the esophagus to the skin of the neck. Until such time as an anterior thoracic esophagus has been made, the children are fed by gastrostomy.

These seventeen patients now range in age from one month to seven years. For eight of them a connection has already been made between the upper esophagus and the intra-abdominal intestinal tract.\* The problems encountered in building the artificial esophagus, in each case, are described in the following pages. Procedures are now in progress for two children, and will soon be undertaken for the remaining seven.

### DERMO-ESOPHAGOPLASTY

The first successful anterior thoracic esophagus in this group was for a patient who is now seven years old. It consists of a skin tube between the esophagostomy and the gastrostomy. The difficulties encountered in this case, by Dr. W. E. Ladd, are similar to those reported by Oschner

and Owens.<sup>1</sup> Fourteen operative procedures, over a period of two years, were required to complete the new esophagus. Healing was slow at the lower end of the skin tube; fistulas developed, which eventually closed spontaneously. Hospitalization was greatly prolonged by these complications.

The anterior thoracic esophagus was completed three years ago. Four months after completion of the skin-tube-gastrostomy junction became necessary, and has subsequently been required at two- to three-month intervals. Furthermore, the patient has occasional discomfort in the skin tube, presumably due to the reflux of irritating gastric juices. That this pain is related to the action of the acid gastric fluid is substantiated by the prompt relief following the ingestion of sodium bicarbonate. Yurasov<sup>4</sup> states that patients with this type of artificial esophagus frequently have a burning sensation in the skin tube. He also reports one case of ulcer of the skin tube and perforation, and remarks that von Hacher had a similar case which terminated fatally.

We are happy to report that, in spite of her past troubles, this alert, attractive little girl leads a normal life, attends school and follows a regular diet. No disfigurement is in evidence when the child is dressed.

In a second case, the lower esophagus was marsupialized to the skin just above the costal margin in order to avoid a dermo-gastric anastomosis. An unsuccessful attempt was made to connect the esophagostomy in the neck with the lower

\* An anterior thoracic esophagus was completed for two other children, but the patients died postoperatively. These cases are also reported in the text.

segment of esophagus by means of a skin tube. Pyloric obstruction developed, probably due to an inadvertent bilateral vagotomy. This caused profuse drainage of gastric secretions through a fistula which developed in the skin tube. A soft rubber

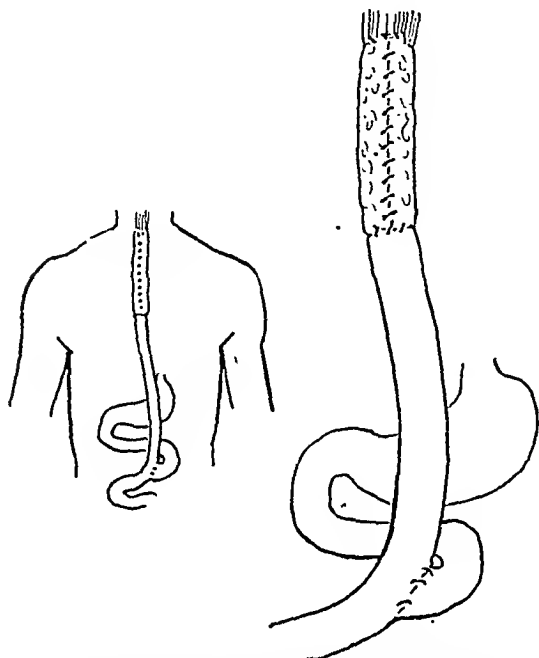


FIG. 1. Schematic drawing of anatomical arrangement for esophagoplasty proposed by Wullstein.

catheter was passed through the pylorus into the duodenum, in the hope of relieving the pyloric obstruction. However, after the catheter had been intermittently in place for seven weeks, a perforation of the duodenum occurred, producing generalized peritonitis, which was the cause of death.

It became clear from these two experiences, as well as from the literature,<sup>1,2,4</sup> that two hazards must be avoided in esophagoplasty: (1) Gastric juices must be prevented from refluxing into the skin tube; and (2) it is not desirable for gastric mucosa to be in continuity with the dermic tube, because the acid secretions of the gastric mucosa probably delay or prevent healing between these structures.

Wullstein<sup>2</sup> postulated a type of esophagoplasty in which the above faults were corrected. He suggested that the jejunum

should be divided close to the ligament of Treitz, and the first one or two intestinal vessels to the lower jejunal segment ligated and divided to free the distal segment of the jejunum. This was then to be brought subcutaneously over the thoracic cage, and the gap between this jejunum and the esophagostomy bridged by a skin tube. The anatomical arrangement is outlined in Figure 1.

Continuity of the intestinal tract was next to be re-established by an end-to-side anastomosis of the jejunum. Theoretically, it would seem that having food pass directly into the small bowel would be objectionable, but reports in the literature<sup>1,3,4</sup> have disproved this objection. These reports have since been confirmed by the results in our own four successful cases with jejunodermal esophagoplasty. These patients are normal children, eat three meals a day and have no complaints.

#### CASE REPORTS

**CASE 1.** (W. W.—267162). As a newborn, this patient had an esophageal atresia and a tracheoesophageal fistula. Dr. W. E. Ladd performed a series of operations, consisting of ligation of the fistula, gastrostomy and marsupialization of the esophagus.

When the boy was one year of age, a beginning was made by Dr. W. E. Ladd on an anterior thoracic esophagus by raising a rope graft from the right axilla and side. One month later its lower end was detached and implanted above the esophagostomy. After an interval of thirty days a skin tube was turned in, which included the esophagostomy and extended almost to the costal margin. The resulting skin defect was covered by the opened rope graft.

Eighteen months later a segment of the jejunum was brought up subcutaneously and anastomosed to the skin tube. The continuity of the jejunum below this was established by a side-to-side anastomosis. No fistula had developed by the tenth postoperative day, and the child began to take fluids by mouth. In a short time a proper diet for his age was being taken.

After a year had elapsed, some solids were refused by the child. Roentgen examination seemed to indicate a narrowing of the dermo-jejunal junction, and dilatation was carried out.

However, no stricture was encountered, a No. 28 dilator passing into the jejunum with ease. In retrospect, it seems that the roentgen report was misleading, and that the little boy simply refused certain solids because he disliked them. Since that procedure, six months ago, this four-year-old child has continued to do well, eating normally and gaining in weight.

CASE II. (D. V.—277277). At four days of age this child was admitted to The Children's Hospital because of atresia of the esophagus and tracheoesophageal fistula. These anomalies were corrected by Dr. W. E. Ladd by ligation and division of the fistula, gastrostomy and marsupialization of the esophagus to the neck.

The formation of an anterior thoracic esophagus was begun by Dr. Ladd and the author when the little boy was twenty-two months old. First, a rope graft was raised in the right axilla and side. Three weeks later the lower end was transferred to the neck just above the esophagostomy. Healing progressed favorably, and at the expiration of three weeks a skin tube was turned in which included the esophagostomy and extended almost to the costal margin. The rope graft was opened and used to cover the turned-in tube. After two months, when the rope graft was well healed, the jejunum was divided close to the ligament of Treitz and freed by the division of two adjacent intestinal arteries. The distal end of the jejunum was brought subcutaneously up to and anastomosed to the skin tube. Last, a side-to-side anastomosis was made to re-establish continuity of the jejunum.

As no fistula developed postoperatively, food was taken by mouth beginning about three weeks after the final operation. Two months later, however, because solids would no longer pass from the skin tube to the jejunum, a gastrostomy was performed and the dermojejunal anastomosis explored. The opening was found to be only 2 mm. in diameter, and the anastomosis was revised so that the stoma measured 2 cm. in diameter. This boy is now (six months later) taking solids and gaining in weight.

CASE III. (S. G.—279539). At two days of age this patient was admitted to The Children's Hospital, where a diagnosis of esophageal atresia with tracheoesophageal fistula was made. Dr. W. E. Ladd ligated and divided the fistula, and several days later carried out gastrostomy and marsupialization of the esophagus.

The little girl did well, and at 21 months was an obese, robust child.

At this time construction of an anterior thoracic esophagus was begun by Dr. Ladd and the author. First, a rope graft was elevated from the right axilla and side and the raw area covered by a Thiersch graft. One month later the lower end of the tube graft was detached and implanted above the esophagostomy. The implantation was successful, and at the end of thirty days a skin tube was turned in on the anterior chest from the esophagostomy to the level of the seventh rib, left of the midline. The turned-in tube was covered by the rope graft.

Three weeks later a segment of jejunum was brought up subcutaneously and anastomosed to the skin tube. A side-to-side anastomosis was then made between the proximal jejunum and the jejunum which had been brought up subcutaneously. Postoperatively, the child did well, except that a fistula developed at the dermojejunal anastomosis. This was treated expectantly, and closed in six weeks.

Although the child's family had been told to give her fluids by mouth during the period of gastrostomy feedings, they had neglected to do so. Consequently, it took months of patience, first on the part of the nurses, and later by the parents, to teach her to take food by mouth. However, she is now taking most of her food orally. Roentgenograms show no evidence of strictures in the new esophagus.

CASE IV. (E. O.—278540). This patient was admitted to The Children's Hospital at two days of age, with a diagnosis of esophageal atresia and tracheoesophageal fistula. Shortly after the admission Dr. W. E. Ladd ligated and divided the fistula. Three days later a gastrostomy was performed. Seven days following the second operation, the esophagus was marsupialized in the neck. The child did well and developed normally.

When the little boy had reached the age of twenty months, the construction of an anterior esophagus was begun by the author with the raising of a rope graft on the right side of the chest. One month later the lower end of the rope graft was freed and implanted above the esophagostomy. A skin tube was turned in four weeks later, extending from the esophagostomy to a point 3 to 4 cm. above the costal margin, and was covered by the rope graft. At the end of another two months a segment

of jejunum was brought up under the skin and anastomosed to the skin tube; and continuity of the jejunum was also established. An uneventful recovery followed. While some redness occurred at the jejuno-dermal anastomosis, no fistula developed.

This child also had to be taught to eat, as all previous feedings had been by gastrostomy and no fluids had been given orally. However, in a few weeks' time all intake was by mouth and continued to be until six months after operation, when soft solids were refused. Roentgen examination indicated an obstruction at the dermojejunal anastomosis. Dilatation was carried out, and since then (two months) fluids and solids are taken with ease. The gastrostomy tube has been removed.

CASE V. (J. McE.—276848). At four days of age this baby was admitted with a diagnosis of esophageal atresia and tracheoesophageal fistula. Ligation of the fistula, followed by gastrostomy, and by marsupialization of the esophagus, were carried out by Dr. W. E. Ladd.

The little boy did well, and when he was twenty-two months old formation of an anterior thoracic esophagus was begun by Dr. Ladd and the author. The dermic portion of the new esophagus extended down almost to the costal margin, and required three operative procedures: raising of the rope graft, transfer of the tube graft and turning in of the skin tube. Four months after the beginning of this series of operations the jejunum was divided close to the ligament of Treitz and two intestinal vessels were cut to free the distal segment. This free segment was brought up subcutaneously, its side anastomosed to the end of the skin tube, and then continuity of the jejunum re-established by a side-to-side anastomosis. One week after this the patient developed a fistula at the dermojejunal anastomosis, which closed only to have a new fistula develop in the midportion of the skin tube. Two unsuccessful attempts were made to close the second fistula, which, however, gradually decreased in size and became free of infection.

About one month after the last procedure the child developed a temperature of 105°F., became comatose, and died in forty-eight hours. Spinal fluid was negative. Permission for a necropsy could not be obtained; it was, however, believed that the cause of death was not related to the surgical procedures, as there was

no evidence of infection along the anterior thoracic esophagus, and no sign of intra-abdominal disease.

In the four completed cases, jejuno-dermal esophagoplasty proved to be a distinct improvement over the procedures which utilize a skin tube between the esophagus and the stomach. Each esophagoplasty was completed in a series of four operations. Hospitalization time averaged five months for each child. In four cases, function was adequate. In the fifth case the patient died while a fistula was still present and feedings had not been attempted on a full scale.

The jejuno-dermal esophagoplasty does, however, present certain difficulties. A minimum of four operations is necessary, making the hospitalization time a long one. A fistula developed in two of the five patients, one fistula closing spontaneously. Two of the children developed strictures at the site of the dermojejunal anastomosis, one requiring excision of the scar, and the other dilatations. Furthermore, it is true that considerable cosmetic disfigurement is inevitable, as is shown in Figure 2.

#### JEJUNAL ESOPHAGOPLASTY

In an attempt to avoid these disadvantages, the possibility of bringing a jejunal segment subcutaneously to the esophagus in the neck was considered. The anatomical arrangement is outlined in Figure 4. If successful, this plan of attack would involve only two operations instead of four and thus shorten the hospital stay. Also, far less scarring would be produced, and it was hoped that neither fistulas nor strictures would develop. Success with this method has been reported by Yudin<sup>3</sup> and Yurasov.<sup>4</sup>

It was believed advisable to carry out a series of animal experiments before attempting this procedure on patients. In planning these experiments, it was recognized that the blood supply of the small bowel in lower animals is less complicated than in human beings. Man has multiple vascular arcades in the intestinal mesen-

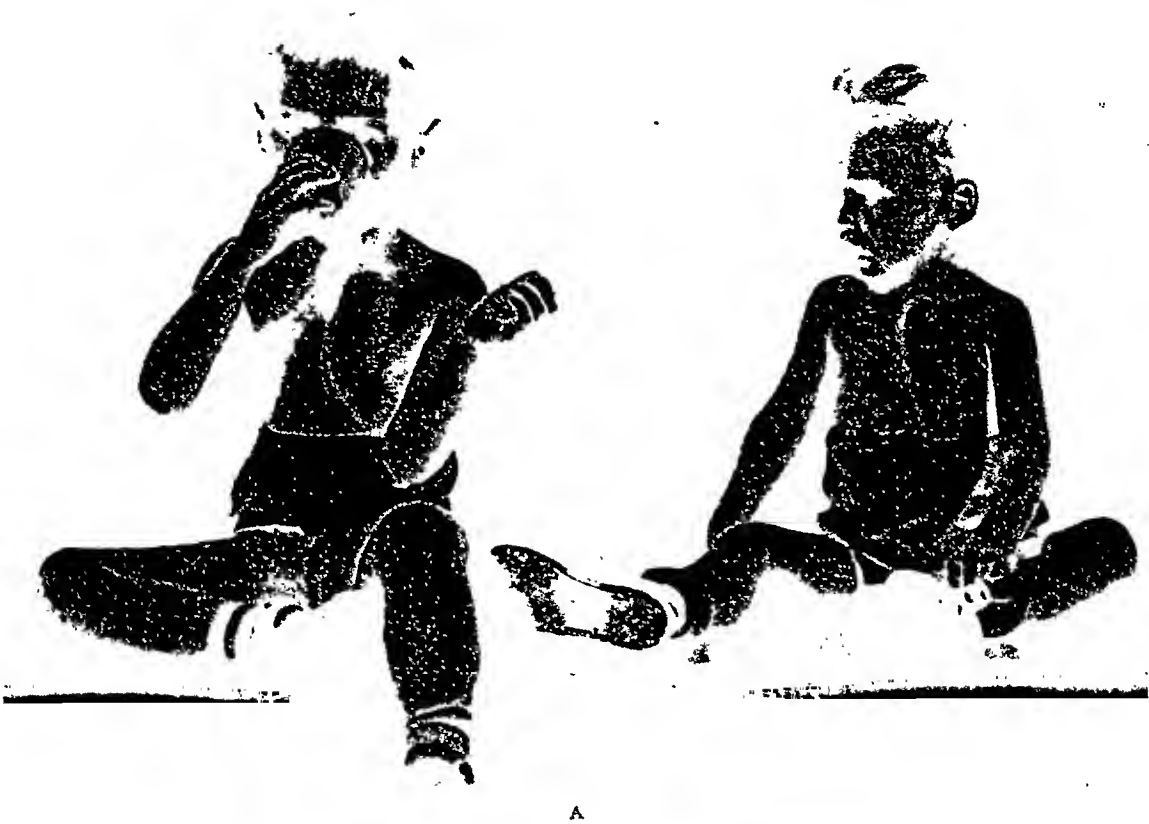


FIG. 2. A and B, both of these patients have had dermojejunal esophagoplasty. There is no scarring visible when the children are dressed.





FIG. 3. X-ray of barium in dermojejunal esophagoplasty.

tery, and thus a richer anastomatic system than do canines, which possess only one arcade. This factor must be taken into account when appraising experimental results and considering their application to man.

In a series of six cats and six dogs the proximal jejunum was divided and the distal segment freed from its normal blood supply by ligating and dividing two or three intestinal vessels so that it could be brought up to the clavicle. Its intra-abdominal continuity was re-established by a side-to-side anastomosis. The subcutaneous end of the jejunum sloughed, and all of these animals were lost.

A second series of six animals was then subjected to the same procedure, except that in these experiments the jejunal segment used was much shorter, necessitating the dividing of only one intestinal vessel, so that the jejunum extended only 3 to 5 cm. above the costal margin. In all of these experiments the jejunum remained viable. These animals were under observation for two weeks to six months. At necropsy, in each case, there was no abnormality in the bowel except for adhesions to the chest wall and subcutaneous tissue.

To bring the jejunal segment up to the clavicle, and to insure its viability, a two-stage procedure was devised. During the first operation intestinal vessels, 10 cm. from the ligament of Treitz, were divided. The jejunum itself was then transacted

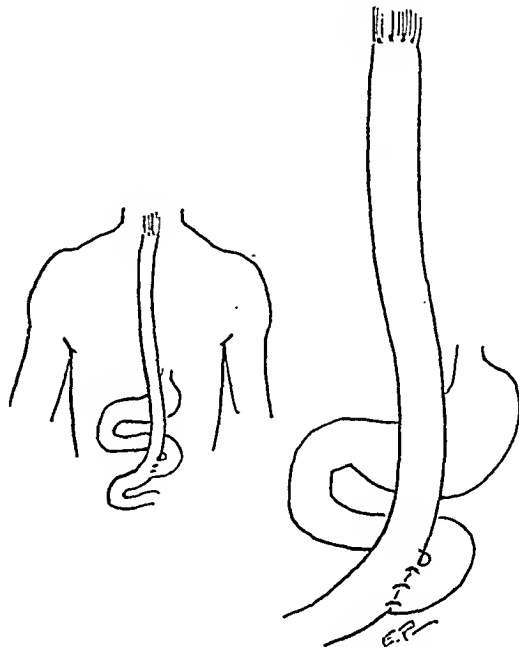


FIG. 4. Schematic drawing of anatomical arrangement in jejunal esophagoplasty.

proximal to the divided vessels. One set of intestinal vessels was left attached to the proximal end of the distal jejunum. A side-to-side anastomosis was then made below the point where the intestinal vessels had been cut. This section of jejunum was wrapped in fibrin film, to prevent the formation of adhesions. The blood supply to this segment of jejunum was now comparable to the blood supply of a rope graft, in that it was limited to the two ends. In ten to fourteen days the collateral blood supply had developed sufficiently to permit cutting the vessel at the proximal end, thus freeing the distal segment of jejunum so that it could be brought up to the clavicle subcutaneously.

A third set of animals, six in all, was subjected to the procedure described above. In each instance the jejunal segment was of sufficient length to extend to the clavicle, and maintained an adequate

blood supply. In each case the jejunum remained viable.

On the basis of these satisfactory experiments, we have carried out similar procedures on four patients. The children were prepared for operation by a five- to six-day course of sulfasuccidine therapy. The operative procedure was tedious, and required great gentleness. A midline incision from xyphoid to umbilicus was used. This gave a good exposure of the superior mesenteric artery and allowed the jejunum and its mesentery to be brought up in the deep cleft of the costal margin, rather than over the protruding ribs on either side of the midline.

The jejunum 10 to 15 cm. from the ligament of Treitz was selected, the peritoneum on each side of the mesentery below this point removed, and the intestinal vessels exposed down to the superior mesenteric artery. The artery and vein below the point of division of the jejunum were separately ligated as close to the superior mesenteric vessels as possible. These were divided, and the adjoining set of intestinal vessels exposed, ligated and cut.

To secure sufficient length of the jejunum to extend to the neck, it was necessary to cut a third set of vessels. To make sure that the end of the jejunal segment would remain viable, the third artery and vein were first occluded with rubber-protected clamps for ten minutes. If no great change in color took place in the jejunum, the vessels were ligated and divided. Two or three additional centimeters in length were obtained by ligating the small vessels as they entered the bowel at the proximal end of the divided distal jejunum. As the mesentery is the limiting factor, 2 to 3 cm. were gained safely by this maneuver. In three out of four cases a sufficient length of jejunum was gained to extend to the clavicle. In the fourth case it was necessary to supplement the jejunum with a short skin tube.

An end-to-side anastomosis of the jejunum was then made to restore continuity of the small bowel. The jejunum was

brought up through the mesocolic shelf, an ample opening was left at the upper end of the abdominal wall to allow the jejunum to pass through. A tunnel was then made under the skin up to the esophagostomy and the jejunum brought up and anchored in place with one suture through the skin. (Figs. 5 and 6.) The end-to-end anastomosis of the jejunum to the esophagus was made ten to fourteen days later, using two rows of interrupted catgut sutures.

An anterior thoracic esophagus has been fashioned by this procedure, with variations, in the following four cases:

CASE VI. (R. O.—275095). At four days of age this child was admitted to The Children's Hospital, and the diagnosis of atresia of the esophagus and tracheoesophageal fistula was confirmed. Dr. W. E. Ladd ligated the fistula, and on subsequent days performed a gastrotomy and marsupialized the esophagus to the neck.

When the little girl was two years of age, Dr. Ladd and the author started the construction of an anterior thoracic esophagus by raising a rope graft on the right side of the chest, extending through the old operative scar. When the lower end of the rope graft was transferred to the neck above the esophagostomy, the graft became discolored and the section down to the old scar was eventually lost in spite of trimming and re-implantation. The rope graft was then extended into the axilla and re-inserted above the esophagostomy. These five procedures consumed three months' time.

As the rope graft was still too short, it was decided to reverse the usual procedure and bring a jejunal segment up subcutaneously rather than to turn in a skin tube first. It was hoped that the jejunal loop could be brought up subcutaneously high enough on the chest so that the short rope graft would be sufficient to cover a turned-in skin tube. The jejunum was divided close to the ligament of Treitz, and three adjacent intestinal arteries divided. By careful freeing of the mesentery, sufficient length was obtained to the distal segment of the jejunum to bring it to the marsupialized esophagus. And end-to-end anastomosis was made between the jejunum and esophagus.

The child did quite well for twenty-four hours, then suddenly developed extensive infection of the anterior chest wall. The abdominal incision was opened, and it was found that a loop of jejunum had herniated between the abdominal wall and the jejunal segment leading

bowel was resected and the esophagus remarsupialized. The child recovered, and now awaits turning in of a skin tube to bridge the gap between the esophagostomy and the jejunum, which extends to just above the costal margin.

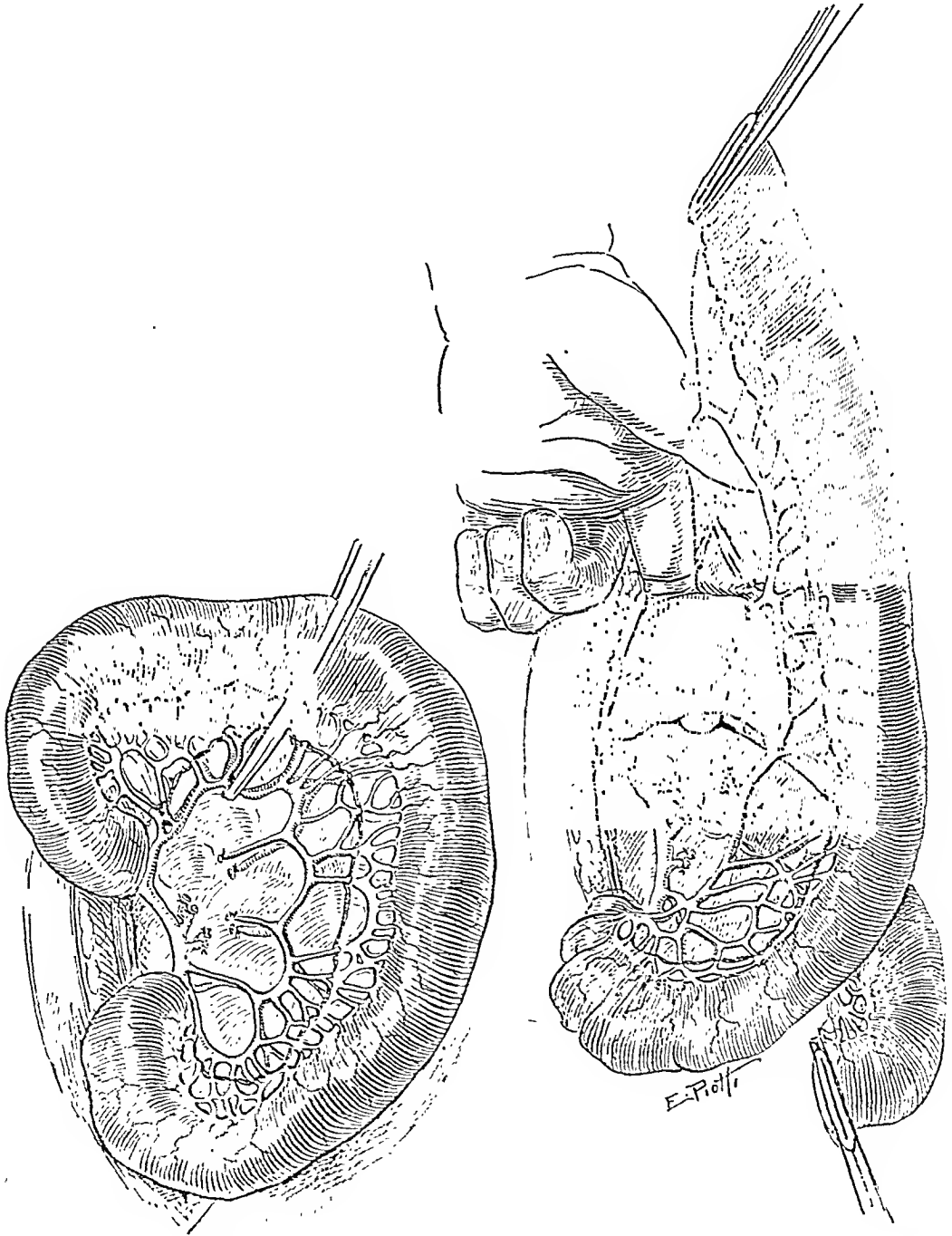


FIG. 5. Drawing showing the division of the jejunal mesentery and vessels which release a length of jejunum which can be brought up to the neck.

to the esophagus, obstructing the blood supply to the bowel above this level. The gangrenous

CASE VII. (D. C.—283160). Shortly after birth a diagnosis of esophageal atresia and

tracheoesophageal fistula was made. Dr. W. E. Ladd ligated the fistula, three days later performed gastrostomy, and followed this in four days by marsupialization of the esophagus.

Formation of an anterior esophagus was begun by the author when this little boy

to a point 2 cm. below the marsupialized esophagus, because of the edema and consequent shortening of the mesentery. The jejunum was left in this position. Two months later, a short skin tube was turned in and covered with a Thiersch graft. One month

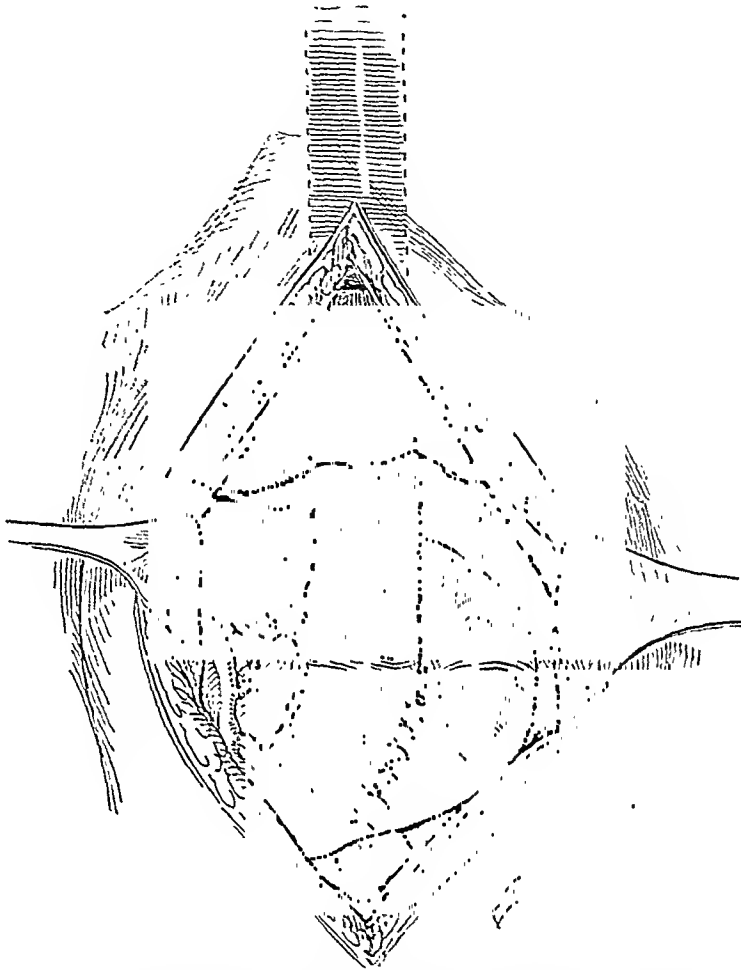


FIG. 6. Drawing demonstrating the end-to-side anastomosis of the jejunum which restores continuity of the intestinal tract after freeing a segment of jejunum.

was twenty-three months old. On the basis of experimental work, it was decided to bring a jejunal segment to the esophagus in the neck by a two-stage procedure. The jejunum was divided 10 cm. below the ligament of Treitz. One intestinal artery and vein were left attached to the proximal end of the distal segment. The next three sets of intestinal vessels were divided, and an end-to-side anastomosis was made to restore continuity of the jejunum below the cut. The freed jejunum and mesentery were covered with fibrin film to prevent the formation of adhesions.

Seven days later the vessel going to the free end of jejunum was divided. Much to our dismay, the jejunum could be brought up only

later the jejunum was anastomosed to the lower end of the skin tube. A small fistula developed, which closed in ten days. One week after the patient was discharged the fistula re-opened, and continued draining for six weeks. It has now been dry for one month, and the child is taking small amounts of liquid by mouth.

CASE VIII. (D. C.—294603). At three days of age this baby was admitted to The Children's Hospital with a diagnosis of atresia of the esophageal with tracheoesophageal fistula. The fistula was ligated, and at two- and three-day intervals the operations of gastrostomy and marsupialization of the esophagus were performed, by the author.



FIG. 7. Photograph of patient with jejunal esophagoplasty. The only scar on the neck and chest is the incision above the left clavicle.

Starting when the little girl was thirteen months old, an anterior jejunal esophagoplasty was performed in two stages: First, three intestinal arterics and veins 10 cm. from the ligament of Treitz were carefully freed and divided. The jejunum proximal to these was divided. The jejunum distal to the point of division was thus freed and could be brought subcutaneously to the marsupialized esophagus. Four weeks later an end-to-end anastomosis was made between the esophagus and jejunum.

The postoperative course was complicated by some infection in the subcutaneous tissue at the site of anastomosis. This cleared after a slight amount of drainage. As this child had not been taking fluids by mouth, it was necessary to train her to eat. At the time of discharge she was taking one ounce of fluid three times daily. Roentgenograms revealed an adequate stoma at the esophagojejunal anastomosis. (Figs. 7 and 8.)

CASE IX. (L. B.—286401). At eight days of age, this child had a series of operations by Dr. W. E. Ladd, consisting of ligation of a tracheoesophageal fistula, gastrostomy and marsupialization of the esophagus to the neck.

When she was two years old, the author began the formation of an extrathoracic esophagus. At the first operation the patient's color was poor, and her blood pressure fell to below 80 systolic. This was presumably due to anesthesia, as little more than an abdominal



FIG. 8. X-ray of barium in jejunal esophagoplasty.

incision was accomplished. Three days later, under cyclopropane anesthesia rather than ether, the child did well and a segment of jejunum was brought up to the marsupialized esophagus. Subsequently, an anastomosis was made between the esophagus and the jejunum. Ten days postoperatively a fistula developed at the site of the anastomosis. The fistula continued to drain for eight weeks after the child was discharged, but she is now beginning to take liquids by mouth.

In the first case of jejunal esophagoplasty, failure was due to two factors: (1) The bowel was anastomosed to the esophagus at the first operation, which invited infection, as an open anastomosis was made in an area of extensive freeing of subcutaneous tissue; (2) the jejunum was not carefully sutured to the peritoneum where the bowel passed through the abdominal wall. A loop of small intestine herniated alongside the jejunum and by pressure reduced the blood supply, so that the jejunum became devitalized and required removal.

The next case was done in two stages. During the first operation three intestinal vessels were ligated and the bowel supplied by these vessels was wrapped in fibrin film to prevent adhesions. At the second stage

the jejunum was brought up under the skin of the chest. The edema and swelling of the mesentery prevented the jejunum from extending to the neck. The 5 cm. gap between the jejunum and the esophagus had to be bridged with a skin tube covered with a Thiersch graft.

In the last two cases, the jejunum was brought up to the neck in one stage, and at a second operation the jejunum was anastomosed to the esophagus. Both of these children developed small fistulas at this anastomosis, but the fistulas closed spontaneously. There is no doubt that this is the procedure of choice, and that it presents far less trouble than had been anticipated.

Jejunal esophagoplasty, as described in the last two cases, has several advantages. Only two operative procedures are required, and the hospital stay is relatively short. The only disfigurement to the patient is a short incision at the base of the neck. Furthermore, it is hoped that fewer strictures will develop in this form of esophagoplasty.

The dangers of this operation can be reduced to a minimum if mobilization of the jejunum is carried only so far as it retains a good color. In the instances in which the jejunum is not of sufficient length to extend to the esophagus, the intervening gap can be spanned by a skin tube. Before such a skin tube is made, the jejunum should be marsupialized to the skin below the esophagus. Two or three months later, when it has been demonstrated that the jejunal opening to the skin is adequate, a skin tube may be turned in. Should the jejunal opening to the skin become stenotic, it can

easily be enlarged before a skin tube is turned in.

#### SUMMARY

Eleven cases of esophagoplasty are reported. There were two deaths; one was directly attributable to preceding operations and the second probably was not related to the previous surgical procedures.

In our experience, dermo-esophagoplasty has proved to be extremely time-consuming, fistulas are troublesome, and strictures at the dermogastic juncture are difficult to prevent or correct.

The use of a skin tube and a segment of jejunum, connecting the dermic tube to the proximal small intestine, by-passing the stomach, is an improvement over a skin tube connecting the upper esophagus to the stomach. The reflux of irritating gastric juice is obviated, and fistulas complicated the postoperative course in only two out of five cases. Strictures occurred in only two out of four cases.

Jejunal esophagoplasty is the operation of choice. Less time is consumed in its completion, and there is minimal disfigurement. Fistulas continue to be a problem and it is too early to say whether strictures will develop.

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# COMPOUND DEPRESSED FRACTURES OF THE SKULL INVOLVING THE SUPERIOR LONGITUDINAL SINUS\*

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THE importance and seriousness of a compound fracture of the skull involving the large venous sinuses of the brain must be fully appreciated before undertaking to operate upon such patients. In particular a compound depressed fracture of the skull involving the superior longitudinal sinus is fraught with great danger. This danger was most vividly described in 1882 by Wharton<sup>1</sup> who near the end of the operative report of his first case of this type stated the following: "Several fragments were removed with the elevator and bone forceps, and upon the removal of the last fragment there was a furious gush of venous blood. Attempts were made to control the bleeding by grasping the walls of the sinus from which it arose with artery forceps, but were ineffectual and the patient promptly succumbed." Wharton profited by this tragic experience. His next four operative cases of compound fractures involving the superior longitudinal sinus not only survived but recovered fully.

In 1901, Wharton presented a paper on seventy collected cases of wounds involving the great venous sinuses of the brain before the Philadelphia Academy of Surgery. Of these, forty cases showed injury to the superior longitudinal sinus with a mortality of 60 per cent.

Since the communication by Holmes and Sargent<sup>2</sup> on injuries to the superior longitudinal sinus during World War I very few reports have been published on this subject.

In 1939, Carlucci<sup>3</sup> reported on one case of injury to the superior longitudinal sinus accompanying a midline depressed skull fracture. There was progressive weakness of the right lower limb. As one of the depressed

skull fragments was elevated there was profuse bleeding from the lacerated sinus. The wound was packed and on the following day both lower limbs were spastic. Following the removal of the packing several days later, the spasticity of the lower extremities disappeared. In a collective review of extradural hemorrhage in 1942 Gurdjian<sup>4</sup> included four cases of dural sinus hemorrhage treated surgically. Pickles<sup>5</sup> in a study of 104 consecutive patients with compound fractures of the skull had no case of injury to the superior longitudinal sinus. In a report by Munro<sup>6</sup> of 215 cases of compound fractures of the skull only one patient had involvement of the superior longitudinal sinus.

The recent experimental studies by Beck and Russell<sup>7</sup> on acute thrombosis of the superior longitudinal sinus in rabbits, cats and dogs have shown rather surprising results. To occlude the sinus they used ligation, irritant coagulants, thrombin, muscle and cotton wool, but in all instances they failed to produce complete thrombosis. These attempts of obliteration of the superior longitudinal sinus were followed by varying degrees of organization and recanalization, and most surprising no functional disturbances. The most likely explanation for the difference in response in man and in the animals used is that in the animals there are not nearly as many cerebral veins emptying into the superior longitudinal sinus and that collateral circulation is adequate to compensate rapidly for such venous interference.

It is timely, therefore, to focus attention again on this serious clinical problem of acute injury and compression of the superior longitudinal sinus. The following reports on two successfully treated patients

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FIG. 1. Case 1. Anteroposterior view showing depressed fracture over the superior longitudinal sinus.



FIG. 2. Case 1. Lateral view showing postrolandic position of the depressed fracture.

have been very instructive and illustrate the value of planned treatment for this type of injury.

#### CASE REPORTS

**CASE 1.** On October 10, 1937, A. S. a ten year old negro boy was admitted to the emergency room of Mt. Sinai Hospital with a laceration of the scalp over the left parietal region. About one hour before admission he was struck over the head by a falling beer bottle and was rendered unconscious for about a minute. There was only moderate bleeding from the scalp.

While being examined the patient suddenly developed a right-sided Jacksonian seizure with clonic movements involving the right arm which then spread to the right leg. This lasted for about one minute and after a brief interval he was fully conscious.

Examination then showed an alert, bright young negro boy with an angular scalp laceration in the parietal region measuring 2 by 7 cm. just to the left of the midline. There was almost complete paralysis of the right leg with marked hypalgesia below the iliac crest. Light touch, vibration and position sense were intact. The deep reflexes were active and equal, but the abdominals and cremasteric responses were absent on the right. There was no Babinski sign.

X-ray films of the skull (Figs. 1 and 2) showed a comminuted depressed fracture of the left parietal bone, 5 cm. in diameter extending to the midline. It was realized that the fracture involved the superior longitudinal sinus.

After the scalp was shaved and all preparations completed for an immediate transfusion, novocaine was infiltrated at the site of the scalp laceration. The wound edges were débrided and a generous exposure made of the depressed skull fragments. These were gently elevated and removed one by one starting furthest away from the longitudinal sinus. A large piece of muscle was obtained and held in readiness. As the last bone fragment which pierced the longitudinal sinus was removed there was a gush of blood, but the muscle placed over the tear easily controlled the bleeding. The muscle was left in place and the scalp carefully closed over it in double layer.

The postoperative course was smooth. Five days after the operation sensation of the right leg was normal and early movement was observed in the right hip. Within a week there was movement of the right leg but no movement in the foot or toes. After several days there was evidence of returning function in the right foot. When allowed out of bed he walked with a slight limp. On November 4, 1937, three weeks after operation he was discharged.

Repeated follow-up examinations over a period of six years showed complete return of motor power and no sensory impairment. He was free of symptoms or seizures and considered his health excellent.





FIG. 3. Case 11. Depressed fracture crossing vertex over the superior longitudinal sinus.

**CASE 11.** On July 21, 1946, at 9:30 P.M. a thirteen year old negro boy was brought to Mt. Sinai Hospital in a semi-conscious condition. About a half hour earlier while walking along the street he was struck over the right side of the head by a falling brick which was thrown from an upper story window.

Examination showed a young, irritable, restless colored boy who from time to time cried out and then fell asleep. However, he could be easily aroused. Over the right parietal region there was a jagged scalp laceration about 4 inches long with driven in dirt and hair, and through which there extruded small bits of brain tissue. There was no stiffness of the neck, but motion of the head caused him to scream out bitterly. The pupils were equal and the fundi were normal. No facial weakness could be demonstrated. There was a left hemiplegia with anesthesia involving the left leg only. The abdominal reflexes on the left were diminished and the Babinski sign was positive on the left. When aroused the patient complained of pain over the front of the neck and down both arms. The pulse was 93 per minute, blood pressure 76 systolic, 50 diastolic.

X-ray films of the cervical region showed no fracture or dislocation, but x-ray films of the

skull (Figs. 3 and 4) showed a comminuted depressed fracture of the right postparietal bone overlying the superior longitudinal sinus.

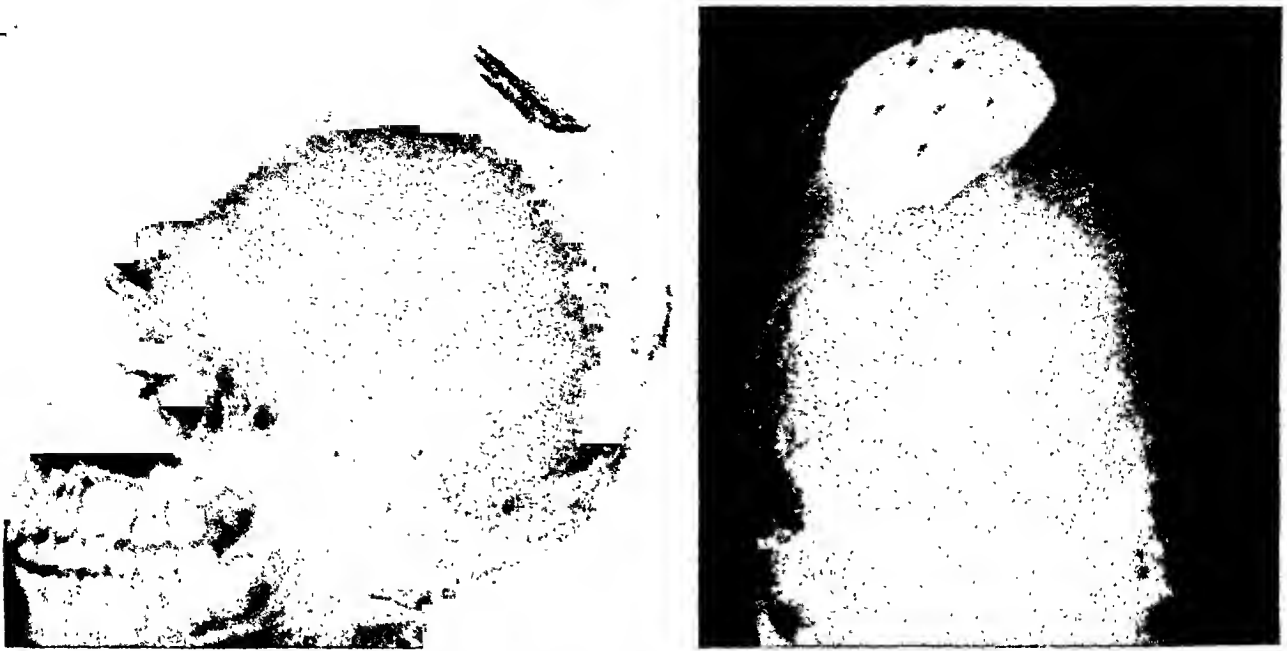
The patient was given 50,000 units of penicillin, 500 cc. of plasma and tetanus anti-toxin. Blood grouping was done and blood obtained for immediate transfusion.

A large area of the scalp was shaved and all preparations were completed to cope with the emergency. The patient was given intravenous sodium pentathol anesthesia. Novocaine was infiltrated in the region of the scalp wound. The wound was then débrided and the depressed comminuted skull fragments were gently elevated and removed one by one beginning at a point furthest from the longitudinal sinus.

The extruding devitalized brain tissue was removed by suction and the bleeding controlled with electrocoagulation. A crescentic dural tear 4 cm. long was repaired. A fair sized block of muscle was kept within easy reach preparatory to the removal of the depressed skull fragment overlying the superior longitudinal sinus. When the fragment was removed the tear in the sinus was immediately sealed with the muscle and held in place. Fortunately, all the bleeding was thereby controlled. The scalp was then closed in double layer. Penicillin therapy was continued.

For several days after the operation the patient was quite irritable and troubled chiefly with pain in the neck and chest. There was no change in the hemiplegia and the Babinski sign on the left was still positive. On the fourth postoperative day the patient had a convulsion on the left side. He was placed on anti-convulsive therapy. Lumbar puncture showed slightly xanthochromic fluid under 50 mm. of water pressure. The fluid showed 625 red blood cells but no leukocytes. Two days later the spinal fluid was crystal clear under 112 mm. of water pressure. Still there was no motion in the left arm or leg, but marked dysesthesia of the left leg. The Babinski sign on the left remained unchanged.

On July 29, 1946, eight days after the operation the first signs of motion appeared in the fingers of the left hand. From then on improvement continued. The patient's personality showed a decided change. He became cheerful, quiet, talkative and at times jovial. By the end of the fourth postoperative week he was able to walk with slight assistance. Sensation was practically normal. Fine finger movements in the left hand were still sluggish.



FIGS. 4 and 5. Case 11. Postrolandic position of the depressed fracture. Showing tantalum plate covering the skull defect.

Because of the large skull defect over so vulnerable an area a cranioplasty was done using a tantalum plate. (Fig. 5.) One week later in spite of penicillin therapy and apparently good wound healing a fluctuant mass appeared under the scalp at the operative site. The regional cervical glands were enlarged and tender. The patient had moderate fever. Aspiration of the mass yielded 12 cc. of dark hemorrhagic fluid which upon culture subsequently showed a growth of *Staphylococcus aureus*. On September 25, 1946, the patient was discharged at which time he walked with a slight limp, dragging the left foot. Power and motion in the left arm was much improved. The deep reflexes on the left were hyperactive. Babinski sign on the left was still positive. Except for slight impairment in position sense of the toes of the left foot no sensory abnormality could be demonstrated.

A follow-up examination three months later showed equal strength in both arms, some weakness of the left leg, chiefly concerned with flexion and extension of the foot, some weakness in flexion of the left knee and moderate atrophy of the left calf and anterior tibial muscles. Babinski sign was still present on the left. There was no sensory abnormality.

#### COMMENT

These two patients present several points of clinical interest. They were both seen within a comparatively short interval after

the injury and offered an excellent opportunity to observe the changing neurological signs. From the history, clinical findings and x-ray films of the skull injury to the superior longitudinal sinus was suspected immediately. In both patients the compression of the sinus was acute and posterior to the rolandic point; that is posterior to the junction of the rolandic venous trunk with the superior longitudinal sinus. Although there was no opportunity to inspect the cerebral cortex adjacent to the wounded longitudinal sinus it may be assumed that the pathological findings were similar to those described by Holmes and Sargent.<sup>2</sup> The clinical course in our two patients closely paralleled their recovered cases. In the cases that came to autopsy Holmes and Sargent found that the pathological condition was chiefly that of stasis as the result of acute venous obstruction. The veins which normally entered into that portion of the injured sinus was swollen, firm and congested. The segment of the brain which was drained by these veins was edematous, flattened and showed minute petechial hemorrhages most prominently in the subcortical white matter.

The return of function in both patients followed a definite pattern. It started in the most peripheral parts of the upper limb,

gradually improving in segments approaching the shoulder, and in the most proximal parts of the lower extremity with improvement progressing peripherally. As has been pointed out by Merwarth<sup>8</sup> in the syndrome of the rolandic vein, progression of functional return in these patients corresponds with our knowledge of cortical localization. Rigidity of the limbs was not noteworthy in either patient. Sensory disturbance cleared very rapidly. There was only temporary dysfunction of the bladder and rectal sphincter. Return of all function was complete in the first patient and the course in the second patient promises a similar result.

#### TREATMENT

In the treatment of a compound fracture of the skull involving the superior longitudinal sinus one must be acutely aware of the dangers that lie ahead and prepare accordingly. On two separate occasions I witnessed the failure of the surgeon to appreciate fully the danger and magnitude of the problem before him. In one case, following the removal of the impacted skull fragment from the tear in the sinus there was a violent gush of blood followed by prompt respiratory cessation and death. In the second patient the tear in the sinus was smaller and the bleeding was finally controlled by packing. There followed a paraplegia of the lower extremities which fortunately cleared up several weeks after the removal of the packing.

When one becomes aware from the clinical examination and studies of the x-ray films that one is dealing with a compound fracture of the skull involving the superior longitudinal sinus, it is well to bear in mind the following: (1) That the sharp edges of the depressed bone fragments may have torn the thin walls of the sinus. These walls are not so readily collapsible because they are really fixed folds of the dura; (2) that not infrequently the bone fragment, usually the inner table of the depressed skull overlying the sinus, may be displaced underneath and so impacted

as to plug the rent made in the sinus. One should therefore not be misled by the very little bleeding encountered at the time of admission or during the early phases of the elevation and removal of the depressed skull fragments; (3) that lacerations of the anterior portion of the superior longitudinal sinus differ from those of the posterior portion of the sinus. The anterior portion is not as adherent to the underlying bone so that with an anterior tear an extradural hematoma is likely to occur, whereas with a posterior tear of the superior longitudinal sinus a subdural hematoma is apt to follow. (4) Occasionally with extensive tears of the sinus air embolism may readily occur and lead to sudden death.

To meet the challenge of impending violent hemorrhage from a wound of the superior longitudinal sinus, the plan of treatment must be simple, systematic and swift. A large area of the scalp should be shaved, an infusion must be functioning well and one or two units of compatible blood must be on hand. A fairly generous block of muscle from the leg or elsewhere must be secured and made easily available on the operating table. Furthermore in the operative procedure one must have a generous exposure of all the depressed skull fragments with sufficient space to permit full and clear view of the injured portion of the sinus. After the débridement of the wound edges the depressed skull fragments farthest away from the injured sinus should be elevated and removed first. Gradually and slowly more of the fragments are lifted and removed with a rongeur, taking little bone at a time. The area of the injured sinus is left for the last. With the entire surgical team on the alert and the transfusion flowing, the last impacted skull fragment is removed and the tear in the sinus immediately sealed off with the muscle. The muscle is held in place with suction over compressed cotton. Further marginal leakage may be controlled with small stamps of muscle, gel foam or oxycel. It may be necessary to suture the muscle to the adjacent dura to aid compression and

prevent slipping. After satisfactory hemostasis the scalp is closed in a double layer.

The other procedure has proven satisfactory in the two patients already reported. Others have met this problem somewhat differently and in a variety of ways. On occasions the impacted bone in the sinus has been left undisturbed. This of course carries the risk of infection, osteomyelitis, thrombophlebitis, meningitis, brain abscess and the like. To control the bleeding from the injured venous sinus measures have been used which include compression of the sinus with gauze or packing, lateral suture of the sinus, ligation of the sinus, closure of the sinus tear with silver clips and under extreme circumstances clamping the sinus with forceps and allowing them to remain in place for three to six days.

#### SUMMARY AND CONCLUSIONS

Two successfully treated cases of compound depressed fractures of the skull involving the superior longitudinal sinus

are presented emphasizing the danger that lies ahead when one is faced with such a serious problem and stressing the value of a planned operative procedure in meeting this danger.

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# GALLSTONE ILEUS

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GALLSTONE ileus is of interest because of its rarity and of importance in that its early recognition and correction by surgical intervention results in a marked decrease in mortality. This holds true since the chief complication of intestinal obstruction, namely, gangrene of the involved gut is always lacking until the late stages of this condition. Yet because of its rarity it is but seldom diagnosed preoperatively being recognized only at autopsy or upon exploration of the abdomen for small intestinal obstruction.

Obstruction of the small intestine due to the presence of gallstones was first reported by Bartholin in 1654.<sup>10</sup> The British Medical Association reported twenty-eight cases of gallstone ileus out of 3,064 cases of obstruction or less than 1 per cent.<sup>1</sup> Various reports estimate that it is the cause of from 1 to 2 per cent of all intestinal obstruction.<sup>3</sup> Until 1925 some 400 cases were all that had appeared in the literature.<sup>2</sup>

Women are more prone to gallstone ileus than men by the ratio of 15:1, while gallbladder disease with stones is only two to three times as common in women.<sup>3</sup> No explanation is presented for this inconsistency.

The average age of a series of seventeen cases<sup>3</sup> was sixty-six years, the youngest in the fifties and the eldest in the nineties. The incidence late in life with the usual late diagnosis is responsible for the high mortality rate variously estimated from 50 to 70 per cent<sup>5</sup> the first figure being from a series of twenty-eight and the second from a series of forty-seven cases. The mortality rate is also increased by excessive surgery when too much time and trouble are spent in locating the source of the offending stone and attempting to care for the pathological condition found about the gallbladder or common duct.

Gallstones may reach the intestine by one of two ways: first, passage by way of the common duct and ampulla of Vater and second, by passage through fistulous tracts between the gallbladder or the bile ducts and an adjacent viscus. This latter way is by the sequence of cholelithiasis, erosion and ulceration, pericholecystitis with formation of adhesions to adjacent structures and perforation and fistula formation through the adhesions. In a series of seventy cases of gallstone ileus in which the route of the stone could be traced thirty-six occurred through a cholecystoduodenal fistula, twenty-five through a cholecysto-ileac fistula, one through a cholecystocolic fistula and seven through a choledochoduodenal fistula.<sup>2</sup>

The size of reported stones causing obstruction is remarkable inasmuch as it is believed that stones up to 2.5 cm. will pass the ileocecal valve.<sup>6</sup> The largest stone reported to the author's knowledge was 6 cm. in diameter and obstructed the duodenum; the largest stone reported in a series operated upon at the Massachusetts General Hospital<sup>3</sup> was 5 cm. in diameter and obstructed the terminal ileum. It is assumed that these reports refer to the smallest diameter of the stones because they were discussed from the viewpoint as being possible causes of intestinal obstruction.

The symptoms are those of any obstruction except that they may be fleeting, transient and recurring. Pain, vomiting and obstipation are usual but distention may never become prominent as some gas may pass the stone. Also the spasm of the intestine about the stone may alternately relax and recur; however, as the stone passes down the narrowing lumen of the intestine complete obstruction is usually the end result.

The diagnosis may often be clouded by the brevity of the obstruction since the stone may often act in a ball-valve manner. The stones may even lie in the intestinal tract for some time without causing symptoms thus obscuring the history of previous gallbladder attacks. Several writers such as Vidgoff<sup>7</sup> and Skemp and Travnick<sup>8</sup> emphasize the fact that frequently the patient has had no preceding symptoms of gallbladder disease. One authority states that 75 per cent of stones which pass from the gallbladder by way of fistulous tracts have never caused symptoms. Roentgen ray examination may be of value in showing the shadow of the suspected stone.

Treatment is surgical and should, as in any case of intestinal obstruction, "be based on suspicion rather than on certainty."<sup>9</sup> Intestinal resection is almost never necessary. If possible the stone should be pushed up the healthy intestine and delivered from the wound, carefully packed off and a longitudinal incision made to free the stone. This incision should be closed under proper asepsis, transversely to obviate the possibility of the later development of a stricture. Drainage is usually not necessary. Ileostomy above the site of the obstruction is rarely if ever indicated and in most instances will add to the mortality. Preoperative and postoperative use of intravenous minerals, fluids and duodenal suction by the Wangenstein method are of prime importance.

#### CASE REPORT

Mrs. E. R., a white female, aged sixty-two years was first seen because of abdominal pain and nausea. Severe cramping abdominal pain had been first noticed on the preceding day. The patient thought that it originated in the right upper quadrant of the abdomen and passed down across the midline to the left lower quadrant. This pain was paroxysmal. Nausea was intense and vomiting severe, the vomitus consisting chiefly of bile. The bowels had moved normally on the day of onset of the pain.

No history of any similar attacks could be

elicited. For the preceding year she had had "gas on the stomach" two or three times monthly which she stated had been relieved by bicarbonate of soda. She admitted that "fat foods" caused gas and a feeling of fullness. About twenty years previously all her "female organs" and appendix were said to have been removed. Chronic constipation had been troublesome for many years. Bronchopneumonia two years before admission was the only previous illness of any consequence.

On physical examination the patient was seen to be an elderly, white female, severely nauseated, vomiting bile at frequent intervals and apparently suffering excruciating pain. Her temperature was 98°F., respirations 20 and pulse 80. She was 5 feet 5 inches tall and weighed 170 pounds. No cardiac or respiratory pathological conditions were noted. Abdominal examination revealed moderate tenderness in the right upper and left lower quadrants, particularly in the latter. No masses, rigidity or distention were demonstrable. Pelvic examination revealed the cervical stump with a large cervical polyp. The rectum was found to be empty and presented no pathological disorder.

A tentative diagnosis of cholecystitis with stones or partial obstruction was made. The patient obtained no relief from morphine sulfate, gr.  $\frac{1}{4}$  hypodermically but was later relieved by a hypodermic injection of the antispasmodic trasentin.

On the second day all symptoms returned in their original severity. Oral trasentin gave no relief from pain but a morphine injection did relieve her to some extent. An enema was given with fair results. The temperature, pulse and respiratory rate were normal. Her blood pressure was 134/84. The physical findings were as before with the addition that the patient was somewhat dehydrated. Peristalsis was normal in activity. Emesis was thick and green. An enema was given and returned uncolored.

The blood count was red blood cells, 4,130,000; hemoglobin, 85 per cent; white blood cells, 14,000; a differential count of 87 per cent neutrophils (no shift to the left), 1 per cent eosinophiles and 12 per cent lymphocytes. A voided specimen of urine showed a specific gravity of 1.021; pH 6.0; albumin, two plus; 20 to 25 erythrocytes per high power field and innumerable pus cells.

On December 29th the condition was essentially unchanged. Intravenous fluids were given. Later in the day abdominal distention was noted for the first time. A flat plate roentgenogram of the abdomen was made which revealed a large shadow in the region of the right kidney pelvis. This was reported as a large staghorn stone of the right kidney. A cholecystogram was later done with failure of visualization of the gall-bladder. A diagnosis of chronic gallbladder disease was made from this finding.

The pain was considerably less on the fourth day but with residual soreness in the left lower abdominal quadrant. Distention was still present but there was no deviation from normal peristaltic activity. As the pathological condition found was not sufficient to explain the symptoms a gastrointestinal roentgenographic study was made. Positive excerpts from the report are as follows:

"The duodenal bulb filled readily and was of average size but peculiar shape and with a long finger-like process of barium extending up from the duodenal cap about 3 cm. in length and 1 cm. in width which presented a "Y" shaped division. This is presumably barium escaping into a dilated common duct and hepatic ducts. At three hours a large portion of the barium meal was still in the stomach and what appeared to be greatly dilated and distended loops of small intestine were seen in the left side of the abdomen. A lesser number were seen in the right side of the abdomen showing a thin shadow of barium. No barium had reached the cecum. Six-hour observation revealed findings almost identical with the three-hour films.

Diagnosis: Small intestinal obstruction (lower ileum). Incompetent sphincter of Oddi with entrance of barium into the common and hepatic ducts."

On the fourth day under general gas and ether anesthesia a low midline incision was made. The lower ileum was adherent to the under surface of the old operative scar. In freeing the adhesions the terminal ileum which was here very thin and dilated was accidentally opened. Proximal to the adhesion a large foreign body was found in the lumen of the intestine. The ileum was incised, the stone removed, the wounds in the intestine sutured transversely and the abdomen closed in layers. A Penrose drain was inserted into the abdominal cavity; the upper abdomen was not explored.

The patient made a fairly uneventful recovery. She was treated postoperatively with constant duodenal suction and intravenous fluids. Normal bowel function returned rapidly. The wound drained about three weeks and healed without other complication.

The pathological report was as follows: "An elongated stone 3.9 cm. in length and 1.9 cm. in diameter presenting a yellowish-gray mottled surface and on crushing portions of the stone a dark reddish-black surface is observed. This stone is definitely not a phytobezoar or a trichobezoar but is a typical gallstone. It is somewhat difficult to visualize the method by which this large stone could pass the cystic and common ducts.

Diagnosis: Cholesterol stone originating in the gallbladder or bile ducts."

#### COMMENTS

The case presented here shows typical fleeting or at least slowly progressing signs of obstruction. The proper diagnosis was hindered by the finding in routine studies of conditions which by themselves could have produced the symptoms presented by the patient. Distention was never marked and feces were passed with enemas on several occasions. This is explained by the ball-valve action of these stones commented on earlier in this paper.

The unusual point about this case which causes it to be reported is the mode of transmission of the stone into the intestine. In all cases reviewed where the mode of transmission was known the stone entered the intestine by way of fistulous tracts; where the mode of transmission was not known it was assumed to have been by way of fistulous tracts. In this case there is presumptive evidence that the stone, large enough to cause intestinal obstruction, passed the common duct and the ampulla of Vater possibly by ulcerating through the latter. First, no fistula is demonstrable by x-ray; second, x-ray study shows a reflux of barium under very slight pressure into the common bile duct and even into the hepatic ducts all of which are enormously dilated.



It is not possible to judge whether the right upper quadrant pain of the early part of the illness was due to the passage of the stone from the common duct or whether the stone had passed long before. Due to the absence of jaundice and other signs of biliary obstruction, the author believed that the stone had entered the intestine previous to the present illness. In all probability it would have passed on to the ileocecal valve and possibly into the cecum but for the kinking of the ileum caused by the adhesions beneath the old midline incision. It was deemed unwise at the time of operation to investigate the conditions about the gallbladder, biliary ducts and ampulla of Vater.

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To increase exposure, especially in the upper abdomen, a transverse incision may be made through the skin and anterior and posterior sheaths of the rectus muscle at right angles to a median incision. This type of exposure may be indicated in certain operations upon the gallbladder, stomach, pancreas, spleen, and transverse colon.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).



# TORSION OF THE SPERMATIC CORD

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**T**ORSION of the spermatic cord, sometimes incorrectly referred to as torsion of the testicle, is a condition caused by a twisting of the spermatic cord and the testicle on its long axis resulting in partial or complete embarrassment of the blood supply to the testicle. It may be acute or chronic. The chronic type is known as recurrent.

*Frequency.* Torsion of the spermatic cord occurs much more frequently than we are led to believe by an examination of the literature. This false impression is gained because many recognized cases have not been reported and many cases have not been recognized. The first case to appear in the literature was published by Delarsiauve in 1840. By 1936, Abeshouse was able to collect 350 cases of which twenty-four were bilateral. A review of the literature by Ewert and Hoffman<sup>19</sup> up to July, 1943, revealed a total of 489 cases of which twenty-six were bilateral, and these authors added four more cases making a grand total of 493 cases up to that time. A review of the English literature since this publication reveals one case presented by Mohardt<sup>18</sup> associated with a tumor of the testicle and a case of bilateral torsion reported by Moulder.<sup>20</sup>

Although torsion has been known to occur in the newborn child and in men who have reached seventy years of age, the great majority of cases occur in young individuals. Abeshouse reports the average age as being 17.7 years. Torsion is found as frequently in the right as in the left testicle. Cryptorchidism is found in 0.1 per cent to 1.0 per cent of the general male population. Since torsion is found as often in these patients as it is in patients who have fully descended testes, it is apparent that undescended testicles predispose to this condition.

*Etiology.* Torsion of the spermatic cord does not occur in the normal testicle. The causes of torsion may be divided into predisposing and exciting. Predisposing causes are as follows: (1) Abnormally large tunica vaginalis with a high investment of the spermatic cord; (2) abnormally long or absent gubernaculum testis; (3) separation of the testicle from the epididymis; (4) inversion of the testicle with the globus major and the globus minor in reverse positions; (5) abnormal attachment of the mesorchium to the lower pole of the testicle which maintains the organ in an almost horizontal position and (6) cryptorchidism. The exciting cause is a spasm of the cremaster muscle which is generally brought on by indirect trauma of a mild degree but the condition has been known to occur while sleeping as reported by Lynch and Thompson<sup>3</sup> and Kretschmer.<sup>1</sup>

Numerous instances of small testicles have been noted during routine physical examinations. This may have been caused by (1) the undeveloped testicle which is small, soft and insensitive; (2) the atrophic testicle which may be classified as *mumps* where the testicle is small, soft and tender; *trauma*, direct or operative and *torsion*. The testicle of trauma and torsion is hard, nodular and insensitive as has been shown by Ormond.<sup>6</sup>

*Pathology.* The actual twist may be intravaginal or extravaginal. The intravaginal type is less frequent and occurs in those patients who have a large tunica vaginalis which is invested high on the spermatic cord. In this type the twist occurs within the sac of the tunica vaginalis and so the tunica is not involved in the process. The extravaginal torsion occurs anywhere between the internal inguinal ring and the attachment of the tunica

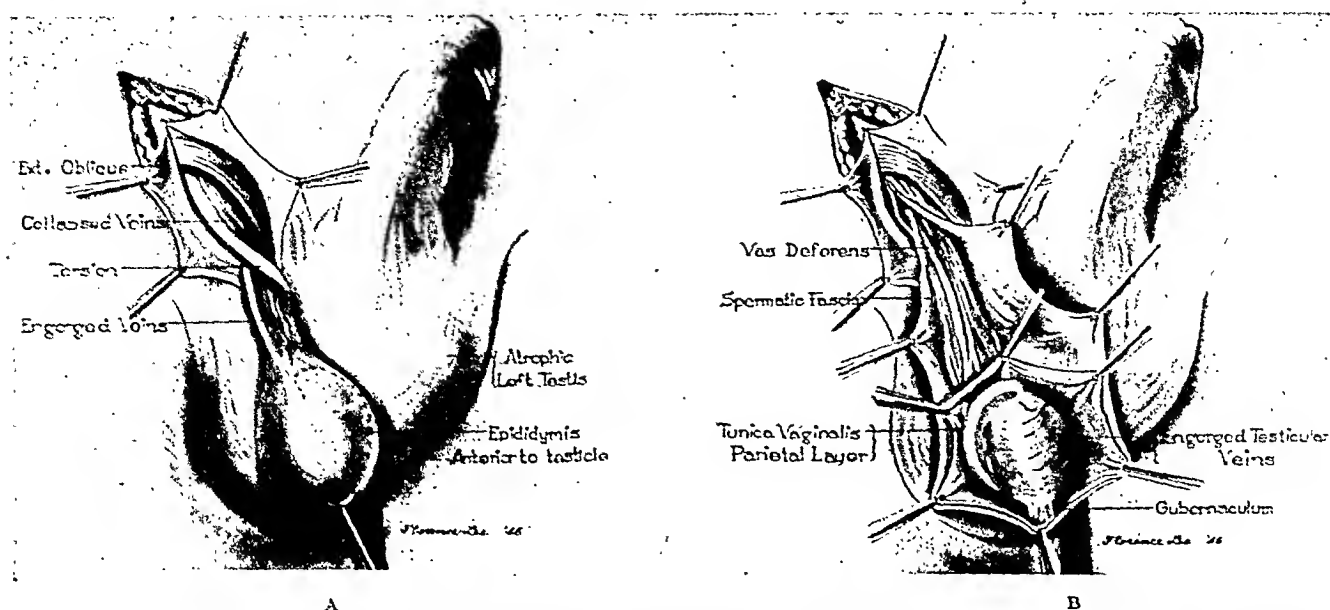


FIG. 1. A, the aponeurosis of the external oblique is opened to show the torsion and the dilated veins. Note the atrophic left testicle; B, the spermatic fascia and the cremaster muscle have been split open and the torsion corrected. The tunica vaginalis has been opened and is left open. Note the long gubernaculum attached to the tunica.

vaginalis to the spermatic cord. The direction of the twist is generally toward the midline. The right testicle turns clockwise and the left turns counterclockwise.

The pathological condition found at operation depends upon the amount of embarrassment to the blood supply and the length of time expired since the onset. The testicle and cord may have twisted any number of degrees; two or three complete turns may have taken place. The veins, because of their thinner, softer walls and lower intraluminal pressure will become obstructed before the arteries. This results in venous engorgement below the site of the twist which progresses to thrombosis and ecchymosis of the spermatic cord and testicle. Edema appears in the cord, epididymis and testicle. This edema extends up to the site of the twist where it is sharply delineated from the normal looking spermatic cord proximal to the torsion. The veins in the proximal portion are empty and flattened. The lesion in the testicle goes on to interstitial hemorrhage, necrosis and gangrene. The appearance of the testicle varies from a gray cyanotic hue to a deep, green-black. Its vessels are engorged. The cavity of the tunica vaginalis contains a varying quantity of fluid under

pressure which may be clear and straw colored or dark and bloody. In the event the lumen of the artery should become obstructed at the onset, the pathological changes will be those of an infarct.

In the recurrent cases, those which have successful manual detorsion accomplished or those which undergo spontaneous detorsion the findings will depend on how many attacks the patient has had and how much damage was done during each attack. Each episode of torsion causes some destruction of the testicle. The destroyed testicular tissue is replaced by fibrous tissue.

**Symptoms.** The symptoms vary according to the location of the testicle, which may be in the abdomen, in the scrotum, or in any interval position and according to the amount of torsion. There is severe testicular pain and tenderness which comes on after indirect trauma. Walking is difficult and the patient leans forward, moving slowly with the legs held apart to keep the scrotum and testicle from striking against the thighs. He sits down very slowly and carefully generally preferring to sit on the contralateral buttock. He lies on the examining table with his knees drawn up, particularly the one on the affected side. The pain

may be referred to the abdomen and simulate an abdominal emergency. This is particularly true in cases of undescended or incompletely descended testicles. The abdominal pain may be associated with nausea and vomiting. Individuals suffering from torsion of the spermatic cord may, but generally do not exhibit nausea, vomiting, shock, fever and leukocytosis. Beare<sup>13</sup> states that repeated attacks of testicular pain without urinary infection is diagnostic of this condition. Physical examination reveals a slightly swollen, very tender testicle situated high in the scrotum. Elevation of the testicle aggravates the pain (Prehn's sign) instead of alleviating it as it does in orchitis and epididymitis. The temperature may go up to 100°F. The testicle feels tense and the epididymis cannot be distinctly differentiated from the testicle by palpation. The determination of the position of the epididymis is of doubtful value except when it is not in its normal position of posterior and medial to the testicle. When the epididymis is normal in its relationships, it must be remembered that the testicle may have rotated 360 degrees or a multiple of it. Ownby and Atkinson<sup>17</sup> quote Dillon's sign. There is edema of the scrotal skin which extends up to the site of torsion and ends abruptly at this point. The scrotal skin is firmly attached and adherent to the underlying scrotal contents.

*Differential Diagnosis.* If the condition is kept in mind, torsion of the spermatic cord will be recognized more frequently. It must, however, be differentiated from other conditions which it may simulate: *Acute epididymitis:* This condition is slow in onset and runs a higher temperature. Leukocytosis is present, the epididymis is swollen, there is a urethral discharge and raising the testicle in the scrotum gives some relief. *Orchitis:* The onset is slow, the temperature is higher, the pain is less, the swelling is greater and the leukocyte count is higher. Prehn's sign is negative. *Traumatic hematocele:* The

testicle is low in the scrotum, the condition is brought on by direct injury and there is ecchymosis of the scrotal skin. *Hydrocele:* The testicle is low in the scrotum, the swelling is greater, there is no pain and the condition is chronic. *Strangulated hernia:* There is a history of a hernia and vomiting is constant and progressive. Since both of these conditions require urgent surgery, the differential diagnosis between them is of academic interest only. The intra-abdominal testicle must be differentiated from such conditions as intestinal obstruction, ureteral spasm or calculi, etc.

*Prognosis.* The prognosis for life in this condition is good. There have been no reported deaths. The prognosis for the testicle is poor in all untreated cases. As mentioned above, there is a certain amount of vascular thrombosis with a concurrent loss of testicular tissue which occurs with each attack of torsion. The fact that detorsion is done manually or occurs spontaneously does not remove the predisposing cause of the condition nor does it relieve the predilection to another attack in the future. Eighty per cent of cases of torsion of the testicle are "acute twistors" which will become gangrenous unless recognized and treated immediately. The remaining 20 per cent are the "recurrent twistors" which will become atrophied with fibrous tissue replacement if something is not done. According to Kreutzman and Strauss<sup>8</sup> the greatest amount of good can be accomplished in the latter group. However, because of the fact that in this group the pain is not too severe and clears up spontaneously, they are reluctant to submit to operation.

#### TREATMENT

Torsion of the spermatic cord is a surgical emergency. The treatment is predicated upon the principal that the obstruction to the blood supply must be undone before irreparable damage has occurred and that the predilection for

recurrence must be removed. It must be kept in mind that torsion does not take place in the normal testicle and therefore the relief of the twist solves the problem for the moment only. Some provision must be made to prevent a recurrence with a possible loss of the organ. The various forms of treatment are:

*Manual Detorsion.* This is best done in the knee chest position. The maneuver can be successfully accomplished in some cases, but since it does not prevent recurrence, Hoffman and Ewert<sup>19</sup> and Wolf<sup>15</sup> believe that this form of treatment should be considered for its historical interest only.

*Open Operation.* It is the general consensus of opinion that open operation is the procedure of choice. The advantages are that the cord can be exposed, the amount and direction of the twist determined, detorsion may be done under direct vision, the condition of the testicle may be seen and the postoperative adhesions will help fix the testicle so that no recurrence will take place. The great majority of authors approached the testicle through the scrotum and then performed either an orchidectomy or an orchidopexy depending upon the findings at operation.

*Orchidectomy.* This procedure is done only after all attempts to revive the testicle have failed. This is especially important if the opposite testicle is undescended or atrophied. Untwisting the cord and relieving the pressure on the cord and testicle which has been produced by the edema are the most essential steps. Wrapping the testicle in warm, moist laparotomy pads is of some value. Any injury to blood vessels can be expected to produce reflex vasospasm. It has been demonstrated both clinically and experimentally by Herrlin, Glasser and Lange<sup>21</sup> that the injection of procaine hydrochloride into the mesentery of the small intestine relieves this spasm by inhibiting the autonomic impulses. If the viability of the organ is questionable, it might

be wise to follow the suggestion of Dr. Herbert C. Chase who advocates the inhalation of pure oxygen while observing the organ in question for a change in color. Finally the use of fluorescein to determine the circulatory adequacy of the testicle should be employed. If it is necessary to remove the testicle, the use of a prosthesis to improve the cosmetic effect should be considered.

*Orchidopexy.* If the blood supply to the testicle is adequate, an orchidopexy of some type should be done to prevent recurrence. Wolf<sup>15</sup> advises fixing the testicle to the scrotum with two or three widely spaced sutures. Kreutzman and Strauss<sup>8</sup> suture the globus minor to the lower pole of the testicle and the globus major to the spermatic cord. The cord is then approximated to the fascia near the external inguinal ring. They do not believe that the testicle should be fixed to the scrotum because it loses its normal mobility. The author is in agreement with Ormond<sup>6</sup> and Ewert and Hoffman<sup>19</sup> that the contralateral testicle should be explored and an orchidopexy done to prevent possible torsion of the other side.

#### CASE REPORT

H. V. A twenty year old Puerto Rican male, was in the act of placing one table upside down upon another table while at work on April 10, 1946, when he was seized with a sharp, severe pain in the right scrotum. Dr. S. S. Geller, who saw him first, made the diagnosis of torsion of the right spermatic cord and referred him for surgery. The patient was seen by me two hours after his accident complaining of severe pain in the right testicle. He walked slowly and with his legs held apart. He sat down gently and rested his weight on his left buttock. Upon being examined in the supine position, he kept both knees drawn up. The right testicle was about one and one-half times its normal size, tense, extremely tender to touch and located high in the scrotum. The spermatic cord was thickened and tender. The scrotal skin was moderately "orange peeled" suggesting early edema. The testicle was in an

almost horizontal position, mobile and the pain was aggravated by raising it. The epididymis could not be palpated. There was no cough impulse and no history of a hernia. The left scrotal sac was small and atrophic. The left testicle was small, measuring 1.2 by 0.8 cm., very hard, nodular and insensitive to pressure. There was no nausea or vomiting. The abdomen was soft with no areas of tenderness and no palpable organs or masses.

The patient was hospitalized and the urinalysis was negative except for occasional spermatazoa seen in the sediment. The blood count was essentially normal with a white cell count of 9,400 of which 60 per cent were polymorphonucleated cells. The temperature was 98.6°F. At operation under spinal anesthesia an incision was made over the right inguinal canal parallel to the right inguinal ligament. The aponeurosis of the external oblique muscle was split, unroofing the inguinal canal. The spermatic cord was seen to be twisted on its long axis 180 degrees clockwise. The veins distal to the twist were markedly engorged and the spermatic cord was cyanotic. The testicle was displaced from the scrotum and found to be engorged, cyanotic, tense and swollen. An attempt was made to untwist the cord but this could not be accomplished. The three layers of the spermatic fascia were split from the internal inguinal ring to the testicle. The tunica vaginalis was opened wide and about 4 ounces of clear, lemon-yellow colored fluid escaped (this was sterile on culture). As soon as the cremasteric fascia had been incised the cord untwisted easily and the color returned to the testicle and cord. Two sutures were used to anchor the testicle in the scrotum so that it could not twist again. The gubernaculum testis was seen to be unusually long. All bleeding points were tied with two pound cotton ligatures. The fascia of the external oblique was closed with interrupted three pound cotton sutures and the skin approximated with interrupted four pound cotton sutures. (The cotton sutures are classified according to their tensile strength.) A scrotal suspensory was placed on the patient and he was returned to his bed in good condition. The following day the testicle and cord were nontender and the patient walked on the fifth day. Upon discharge from the hospital the testicle was slightly softer and smaller than normal.

To this date, two months later, the testicle has shown no evidence of atrophy.

#### COMMENT

The gubernaculum testis was about three quarters of an inch long and is believed to be the predisposing factor in this case. In view of the accepted theory that the exciting cause of the actual torsion is a spasm of the cremaster muscle, it seemed logical to split this muscle from the internal ring to the testicle. This should serve a threefold purpose: (1) It should relieve all pressure on the dangerously edematous and engorged spermatic cord and its vascular channels by opening the envelope which contains them; (2) it makes untwisting of the cord more simple and (3) it should prevent recurrence because of the post-operative adhesions which will form. It is easier to do this by unroofing the inguinal canal than by a scrotal approach. The tunica vaginalis should be opened and left open in order to relieve the pressure on the testicle and thus aid in maintaining its viability. The procedure of everting the tunica vaginalis adds additional trauma to an already precarious condition.

This patient spoke no English and so it was difficult to obtain an accurate history but even with the aid of an interpreter, no history of injury or attack of pain in the left testicle could be elicited. He denied having had mumps. In fact the patient was not aware that the left testicle was abnormal. Inasmuch as this testicle was small, hard, fibrous and nodular and the patient denied having had mumps or having suffered any trauma to it, it is not at all improbable that he had had an attack of torsion of the left spermatic cord in the past with a resultant atrophy of the testicle. Since the diagnosis of torsion of the left spermatic cord would have to be based upon circumstantial evidence, this case is not being reported as bilateral torsion of the spermatic cord.

## SUMMARY AND CONCLUSIONS

1. Torsion of the spermatic cord is more frequent than is generally supposed.
2. The causes and types of torsion are enumerated.
3. All cases of torsion merit an orchidopexy to avert a future testicular tragedy.
4. Attention is drawn to the possible occurrence of torsion in the contralateral testicle.
5. A procedure has been suggested to determine the adequacy of the blood supply to the testicle.
6. Another operative approach has been suggested.
7. A case of torsion of the spermatic cord is reported.

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# INCARCERATION OF THE STOMACH IN AN UMBILICAL HERNIA

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THE following case report illustrates the extreme emaciation that may result from a mechanical obstruction of the stomach when incarcerated in a large umbilical hernia.

quantities of undigested food. The vomiting attacks were not accompanied by pain. For two years the vomiting continued at irregular intervals. Constipation was persistent for one year during which time she had but three



FIG. 1. A, photograph of patient when she weighed 285 pounds; B, appearance of patient when she weighed 95 pounds; C, photograph taken four years after operation; weight 243 pounds.

## CASE REPORT

A female patient, aged forty-nine, was admitted to the University of Kansas Hospitals, November 9, 1941, complaining of a rupture. She stated that the rupture first appeared twenty-two years ago soon after an accident in which a cow stepped on her abdomen. The hernia did not increase in size very rapidly until after the birth of her two children five and eight years following the accident. Two years before admission to the hospital the hernia had grown very large and she began to have attacks of vomiting. At times she would vomit large

spontaneous bowel movements. She had taken many different kinds of laxatives without much benefit and finally enemas were necessary to empty the colon. Her weight two years before entering the hospital was 285 pounds. There was a gradual loss of weight for two years and when she entered the hospital, her weight was 95 pounds. (Fig. 1.)

The most striking features of the examination were the extreme emaciation and a large pendulous pedunculated ventral hernia which hung below the pubes. It measured approximately 25 by 30 by 35 cm.

X-ray studies with barium in the stomach

showed more than one half of the stomach in the hernial sac (Fig. 2). With a incision across the cecum, ascending and transverse colon could be demonstrated in the sac.

Laboratory examination there were normal except as vitamin C deficiency. The total serum protein was 6.5 Gm.

At operation an elliptical incision was made about the perile of the hernia extending from one flank to the other. The elongated stomach and gastro-splenic mesentery were found adherent to the anterior wall of the hernial sac. The cecum, ascending colon, transverse colon and descending colon were in the sac. The mesentery of the colon was long and the hepatic and splenic flexures could not be identified. The sac was removed and the hernia was closed with silk by the Mayo method.

Recovery from the operation was uneventful. Increase in weight began soon after the patient was discharged from the hospital. In September, 1948, four years after the operation, the patient reported her weight as 215 pounds. There have been no stomach or bowel disturbance since the operation.



Fig. 2. Stomach and mesentery in the hernial sac.





# ACUTE TRAUMATIC ANEURYSM OF THE PALM

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THE purpose of this paper is to add a case of true acute traumatic aneurysm of the palm to the literature. This lesion is relatively rare; only one case was seen in a large overseas General Hospital in forty-four months. Zuckerman and

The patient was again seen nine weeks later at which time an aspirating needle was inserted into the lump and bright red blood was obtained. The patient was then sent to the hospital.

Examination on April 9, 1945, showed a well nourished white male whose only obvious abnormality was a pulsating tumor occupying the medial aspect of the left palm about one-half the distance between the wrist and the proximal flexion crease of the palm. There was no evidence of a skin lesion in this area. The tumor measured 2.5 cm. in diameter. There was no bruit or thrill. The mass could be compressed and partially emptied with some difficulty. Occlusion of the radial pulse did not change the pulsation. Occlusion of the ulnar artery stopped the pulsations. Blood pressure of the left arm was 120/78 and of the right arm 110/80. A diagnosis of traumatic aneurysm of the ulnar branch of the superficial palmar arch was made and this diagnosis was confirmed by an arteriogram.

Under sodium pentothal anesthesia, a short incision was made just lateral to the hypothenar eminence of the left palm. When the palmar fascia was incised, a mass about 1 cm. in diameter was identified (Fig. 1) attached at the proximal and distal ends by a normal appearing ulnar artery. The tourniquet was released long enough to identify the mass definitely as the pulsating tumor. The artery was then ligated proximally and distally to the tumor and it was removed.

The wound healed per primam. The patient was discharged from the hospital to duty on the ninth postoperative day and was subsequently seen one and two months following his discharge, at which times his hand was asymptomatic and he was performing his regular duties.

The pathologist's report was as follows: "Gross: specimen consists of an arterial segment, the central portion of which is greatly dilated and measures 1.2 cm. in diameter. Microscopic section reveals a roughened intima



FIG. 1. Anterior view showing removal of aneurysm.

Proctor<sup>1</sup> recently published an excellent review of the literature on this subject and added one case to the literature.

## CASE REPORT

H. W., a twenty-one year old white soldier struck the handle of a screw driver with the left palm while attempting to open a case. Following the injury, the palm became tender and one week later he noticed a lump at the site of the injury. He was seen at sick call and the diagnosis of contusion was made. A splint was applied and the patient was placed on quarters status. One week later, the splint was removed and the patient was returned to duty.

1. The purpose of this document is to provide a comprehensive overview of the current status of the project and to identify the key areas for improvement. The information presented here is based on the most recent data available and is intended to serve as a guide for decision-making.

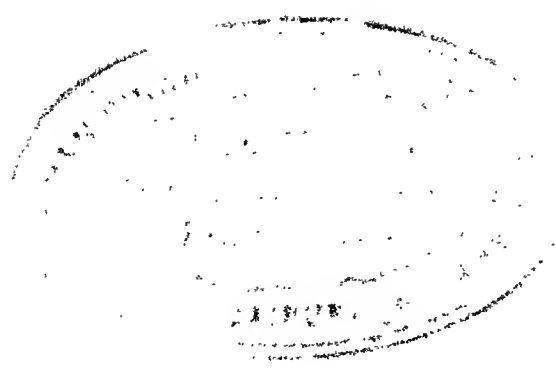
2. The project has made significant progress since the last report, with several key milestones being achieved. However, there are still a number of challenges that need to be addressed in order to ensure the successful completion of the project.

3. The following table provides a summary of the project's performance over the last quarter, highlighting the areas of strength and the areas that require further attention.



4. The project team has identified a number of key areas for improvement, including the need to enhance communication and collaboration between the different teams involved in the project. It is recommended that a regular meeting be held to discuss the progress of the project and to address any issues that arise.

5. The project team is committed to ensuring the successful completion of the project and to providing the highest quality of service to the client. It is hoped that the information presented in this document will be helpful in achieving these goals.



# UTERUS DIDELPHYS WITH ECTOPIC TUBAL GESTATION

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AND

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WHILE instances of uterus didelphys, particularly when associated with ectopic tubal gestation, are not common, the general anatomical findings of the condition are familiar. However, no reference has been found in the literature relative to a peritoneal septum in the pelvis such as has been observed in the patient being reported. It is possible that the pelvic septum represents a further and adventitious anomaly. On the other hand, very few patients having uterus didelphys have been examined in the absence of gross anatomical distortion due to pregnancy, consequently the presence of such a septum may have been overlooked. A brief résumé of the clinical and anatomical findings in this patient follow:

## CASE REPORT

A twenty-five year old, white female, former army nurse, married five months, had always had normal menstrual periods. Her last menstrual period was February 20, 1946. On March 30, 1946, she began having slight painless vaginal bleeding. On April 2nd, she developed stabbing pains in the right lower quadrant and was treated by a local doctor. The following day three large, dark clots of blood which contained no fetal or placental tissue were passed from the vagina. On April 5th, similar vaginal bleeding recurred and she was admitted to the local hospital where ergotrate was administered intramuscularly. The ergotrate was discontinued on April 7th, when she developed severe cramping pains in the right lower quadrant. On April 9th, the patient was discharged from the hospital. She had no abdominal pain but still noted a slight amount of dark vaginal bleeding occasionally. This type of vaginal bleeding continued intermittently until the night of April 17th, when moderate, constant pain developed in the right lower

quadrant and the patient was brought to this hospital.

On examination at this hospital her temperature was 101°F., blood pressure 94/56 and pulse 112. She appeared sallow but was alert and did not manifest any other symptoms of shock. Pelvic examination revealed a double uterus and complete septate vagina with the cervixes partially fused in the midline for a distance of 2 centimeters at their lower most ends. There was a tender mass indistinguishable from the right uterus about the size of a two months' pregnancy. The left uterus was normal in size and consistency and was not tender. No adnexal masses were palpated. Blood studies revealed the hemoglobin to be 80 per cent. The red blood cell count was 3,700,000 and the white blood cell count 8,500. The differential blood count showed 78 per cent polymorphonuclear leukocytes and 22 per cent lymphocytes. The urinalysis was negative. The admitting officer considered the patient to have an incomplete abortion possibly with infection present. The patient was treated with 30,000 units of penicillin intramuscularly every three hours.

During the early morning of April 18th, the pain in the right lower quadrant became more severe and was accompanied by marked urinary urgency. Pelvic examination revealed a mass in the right lower quadrant which extended upward to within 2 cm. of the right anterior superior iliac spine and medially just to the right of the midline. The mass was exquisitely tender and there was marked rebound tenderness over the entire lower abdomen. A diagnosis of ruptured, ectopic, right, tubal gestation was made and an emergency laparotomy was performed.

The abdomen was opened through a low midline incision. On opening the peritoneal cavity a large quantity of dark blood was encountered. This was aspirated and the intestine packed off. There was a large mass in the right adnexa composed of the right Fallopian tube,

right ovary and massive blood clots. The blood clots were extracted. An examination of the right adnexa revealed that the ectopic pregnancy had implanted itself in the right Fallopian tube and had recently ruptured the tube. The right ovarian vessels were doubly clamped and ligated. The right mesosalpinx was clamped and ligated. The intramural portion of the right Fallopian tube was excised from the cornu of the right uterus. The defect in the cornu of the uterus was repaired by interrupted chromic catgut sutures. The right round ligament was grasped a short distance from its attachment to the cornu of the right uterus, brought behind the uterus and sutured there with interrupted chromic catgut sutures. This structure was utilized for giving support to the right uterus and for covering all raw surfaces at the cornu of the right uterus. All bleeding was under control at the completion of this stage of the operation. The blood clots which were accessible were removed and all blood aspirated from the abdominal cavity.

Exploration of the pelvis revealed that two uteri were present. The uterus in the left side of the pelvis was about normal in size, while the one in the right side of the pelvis was slightly larger. Separating the two organs was a septum, composed of two layers of peritoneum enclosing a sheet of areolar tissue, which divided the pelvis sagittally into two halves. This septum of tissue was continuous with the mesentery of the sigmoid colon and extended from this structure and the rectum anteriorly to the bladder and the region of the space of Retzius. However, the ventral margin of the pelvic septum had no attachments in the sagittal plane with the perietal peritoneum of the anterior abdominal wall except in the region immediately ventral to the bladder. One round ligament, one Fallopian tube and one ovary were present on the left side of the left uterus and the right side of the right uterus, respectively. After completing the exploration the abdominal wound was closed in layers. The patient had an uneventful convalescence.

#### COMMENTS

A possible embryological explanation of the pelvic septum discovered in this patient is offered. After the cloaca has divided into the urogenital sinus and

rectum, the Müllerian ducts join the former. They come to lie side by side and then fuse, effectively intervening between the two derivatives of the cloaca. In uterus didelphys, the two Müllerian ducts are in apposition only at their most caudal end and never intervene between the intraperitoneal bladder and rectum.

As growth progresses, the bladder migrates ventrally and the rectum dorsally relative to the uterus, and the peritoneum is applied to them, forming the vesico-uterine and recto-uterine pouches. If the peritoneum does not fill the pelvis prior to the fusion of the Müllerian ducts, it must be drawn down to the region of the cervix, near the anterior and posterior fornices. In uterus didelphys, a tropic effect such as this may be missing in the midline only. A sling of peritoneum may be left between the bladder and rectum, elongating in the sagittal plane as they separate. At the same time, the peritoneum may apply itself to the region of the cervix except where they are joined. According to this hypothesis two soft tissue pelvic fossae would be formed, divided by a septum which contains nothing but areolar tissue. This in effect is what was found in the pelvis of the patient discussed.

The anatomy of the pelvis and vagina in this patient offer several interesting clinical problems. When uterus didelphys is present, colpotomy should be done in a lateral direction. Furthermore, if this procedure is performed for diagnostic purposes, it should be carried out bilaterally. It is possible that in order for the patient to be delivered through the vagina a plastic procedure may have to be performed upon the double vagina. If this is necessary but is not done, the patient could be delivered by means of cesarean section.

It is possible that a subtotal hysterectomy should have been performed upon the right uterus. Subtotal abdominal hysterectomy is suggested because of the partial fusion of the two cervixes at their lower most ends. In addition to the technical difficulties

offered by the anomaly, the removal of the right cervix may result in sufficient scarring and distortion of the remaining cervix to interfere with subsequent normal delivery. However, there was no evidence that both uteri had not menstruated at the same time. Furthermore, it was believed that the patient's condition, while satisfactory, did not justify a more extensive procedure than that which was done.

There was no evidence that the patient could not become pregnant in the left uterus. The left tube and ovary, as well as the uterus, appeared normal in all respects. If the sagittal pelvic septum dividing the pelvis into two halves interferes with the proper enlargement of the uterus or interferes with the pregnant uterus lifting itself out of the pelvis, this septum will have to be removed by an abdominal operation at some future date. If the two uteri menstruate alternately and in addition to the resulting inconvenience are responsible for the patient developing a secondary anemia, a hysterectomy on the right side can be performed. This procedure could be combined with a

plastic operation upon the peritoneal septum in the pelvis already described.

As stated previously, the operation performed for ectopic tubal gestation was considered a life saving procedure. It was felt that any plastic procedure should be deferred until some future date when the patient is in excellent condition and circumstances have been clarified as to what plastic operation should be performed so as to place the patient in a more normal and healthy state.

#### SUMMARY

1. Uterus didelphys, particularly when associated with ectopic gestation, is an uncommon condition. A patient in which this situation existed has been reported.
2. In addition to uterus didelphys, a pelvic septum, which divided the pelvis sagittally into two halves was found in the patient reported. A possible explanation of the embryological development of this structure has been offered.
3. Some of the anatomical and clinical problems associated with uterus didelphys have been discussed.



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# New Instruments

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## NEW PRINCIPLE IN MECHANICAL ABDOMINAL RETRACTION\*

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IT is almost trite to say that good exposure is the *sine qua non* of efficient abdominal surgery. In war surgery when the routine incision for abdominal exploration often extended from ensiform to pubis, exposure was seldom a problem

as other considerations necessitate a much smaller incision. The problem of exposure then narrows down essentially to the problem of good retraction. Especially is this problem of adequate retraction of importance in the smaller hospitals which in the

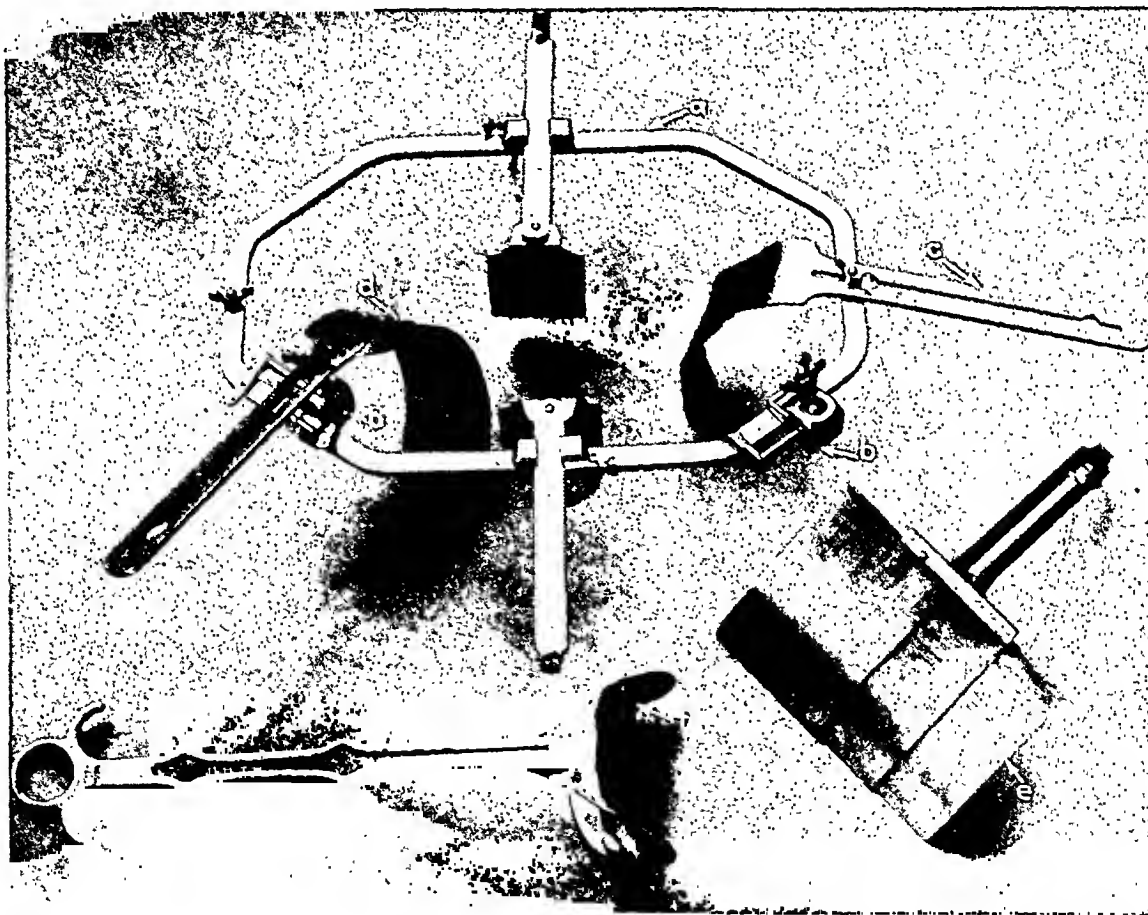


FIG. 1. The retractor and its component parts. *a*, Octagonal frame; *b*, universal joint and clamp; *c* and *d*, blades fixed respectively to the frame and universal joint; *e*, expanding blade; *f*, standard bladder retractor blade.

which, incidentally, was probably an important factor in the excellent results obtained in our overseas hospitals. In civilian practice, however, cosmetic as well

aggregate serve a large proportion of our population.

In the larger medical centers enough residents or internes are usually available

\* Manufactured by Edward Weck & Co.

so that in a major operation retractors may be held by hand. However, certain factors mitigate against the efficiency or even the desirability of hand retraction. The first assistant must not be distracted by the necessity of occasionally holding a retractor

important in long drawn out deep abdominal procedures. From the point of view of the downtrodden retractor pullers, no less than that of the operator, a device which would render hours of physical effort unnecessary while maintaining the

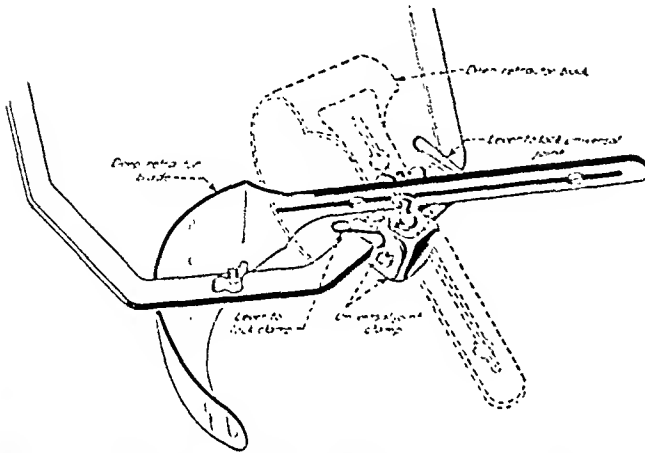


FIG. 2. Showing the angulation and mobility available by use of the universal joint.

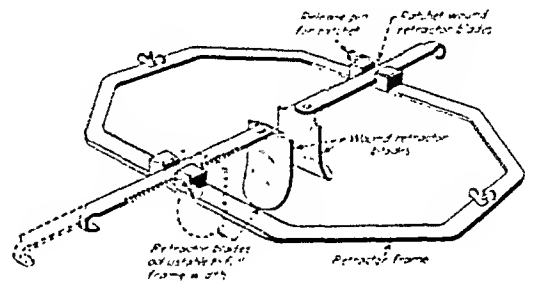


FIG. 3. Illustrating ease of width adjustment of incision.

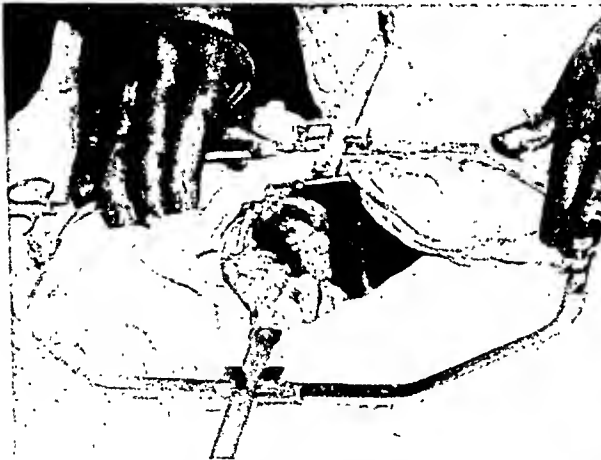


FIG. 4. Retractor without accessory blades at start of cholecystectomy.

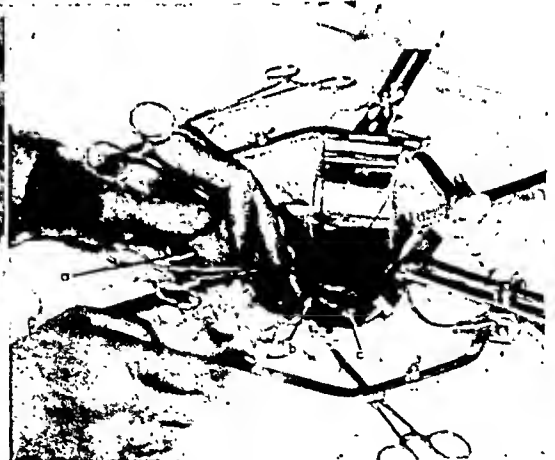


FIG. 5. Retractor in cholecystectomy showing cleanly walled-off field of operation. Note clearly defined anatomical landmarks: a, gallbladder; b, ligature on cystic duct; c, common duct.

or replacing retractors held by a tiring second assistant. In work of major scope three assistants are often used; here the work is just as apt as not to be impeded by the crowding around the table. The very human element of fatigue on the part of the retractor holders is prone to become a problem in precisely the places where steady and adequate retraction is most

adequacy of the exposure would be a priceless gift. Hence, even in our largest medical centers with their plethora of assistants mechanical retraction which could accomplish what hand retraction does would be a definite boon.

In the smaller community hospitals no profusion of assistants is ordinarily available. Here the problem of adequate retrac-

tion has customarily been solved by the use of the available self-retaining retractors. The deficiencies of these retractors are too well known to require extended comment.

Having worked in a smaller suburban

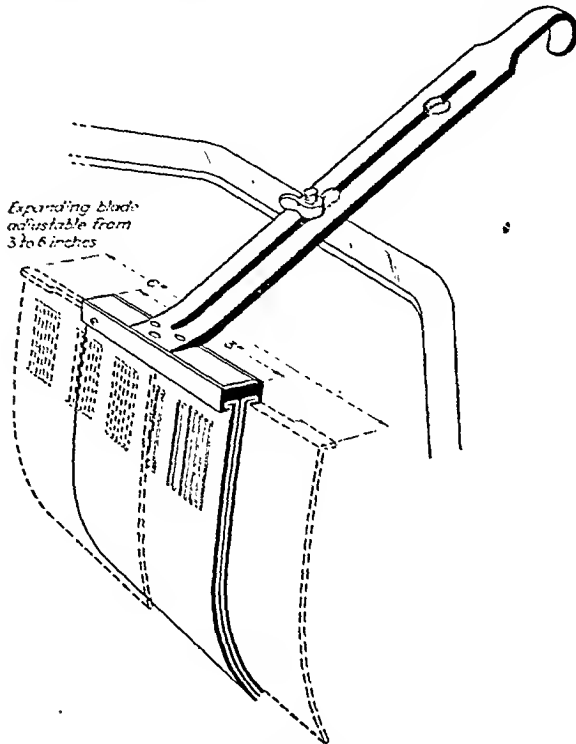


FIG. 6. Variable width blade showing normal and expanded positions.

hospital for a number of years under these handicaps, it occurred to the writer that two essential elements were missing in any of the then available self-retaining retractors. The first was that in any of the existing instruments the retraction could not always be made to work precisely where the operator intended it to. This was due to the fact that although the handle could usually be slid along the frame, the blade being fixed to the handle at a constant angle, always exerted its restraining effect in a plane roughly perpendicular to the handle (and hence, to the anterior abdominal wall.) Retraction is frequently needed, however, at a point so deeply placed, and so far laterally beneath the incision that no standard blade can reach it; to do so, the retractor would need an awkward, long blade fixed at an acute angle to the handle.

This feature was solved by the use of a

universal joint which can be attached anywhere along the circumference of an octagonal frame. Any slotted standard retractor can be attached to this joint and by tilting the handle upward the point of the blade can be made to reach deep underneath and laterally to the incision. The universal joint can be firmly locked at any point on the frame and the retractor having been placed at any desired angle securely locked at the joint (Figs. 1 and 2.) Figure 1b shows the two universal joints in place on the octagonal frame *a*. The ratchet arrangement on the octagonal frame enables the wound to be opened and secured at any desired width. (Figs. 3 and 4.) Also shown in Figure 1 are a slotted malleable retractor *c* which has been found very useful, a slightly modified Deaver (with slotted handle) *d* and a standard bladder retractor *f*. Any of these may be attached either directly to the frame (as in *c*) or to the universal joint (as in *d*). The standard Horgan, Bland or Balfour blades may be used on the instrument without modification.

Figures 4 and 5 show the retractor being used in a cholecystectomy; in Figures 7 and 8 its use in a pelvic laparotomy is illustrated.

The second element in which standard mechanical retractors were found to be deficient was that no blade was wide enough to wall off adequately the constantly shifting intestines and keep them away from the field of operation. Six inches was found by experiment to be the optimal width for retraction of this type but a six-inch blade would be totally unwieldy. This difficulty was overcome by construction of a new type of blade of standard width which could by a simple movement be expanded to any desired width up to 6 inches. (Figs. 1e and 6.) The angle of the blade to the handle was designed specifically to make the blade lie parallel to the superior border of the sacral promontory, so that in a pelvic laparotomy with the handle lying flat on the abdomen, the expanding blade covering a





FIG. 7. Retractor in pelvic laparotomy showing excellent exposure and use of expanding blade.



FIG. 8. Retractor in hysterectomy showing ease of exposure. *a*, uterine vessels; *b*, round ligaments; *c*, ovarian vessels.

lap pad very effectively seals off the intestines. This is clearly shown in Figures 7 and 8. This blade was found to be most useful in other procedures of abdominal surgery besides pelvic laparotomies; held by hand it furnishes adequate retraction when working in the lateral gutters where mechanical retraction with any instrument has been found to be inadequate. It is also very useful in gallbladder surgery (Fig. 5) as well as lower abdominal procedures such as abdominoperineal resection.

The two outstanding deficiencies of available self-retaining retractors—the inability to place the retractor blade at the desired angle or depth and the lack of width of the retractor blade itself—have been completely corrected by the use of the two new principles herein described, the use of the universal joint and the expanding retractor.

#### SUMMARY

A self-retaining abdominal retractor embodying two entirely new mechanical principles is described. The retractor possesses the following advantages:

1. By means of a universal joint the blades can be held securely at any position, angle or depth desired.
2. An expanding blade provides efficient visceral retraction to a width of 6 inches.
3. A malleable retractor and a Deaver blade slightly modified may be used as an integral part of the instrument.
4. The standard slotted blades of existing self-retaining retractors may be used interchangeably with the instrument.

Many thanks are due Dr. Sol Shlimbaum for his suggestions as well as Drs. Charles C. Murphy, Earl B. McCoy and Fred Bromberg for their cooperation during the development of this instrument. Thanks are due also to Dr. Anthony Kohn, the author's associate, for help in the preparation of this article.



# BIOPSY DRILL PUNCH\*

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NEW YORK, NEW YORK

**A**LTHOUGH in modern practice the removal of tissue from suspected cancerous lesions for biopsy is no longer regarded as hazardous, nevertheless the removal of a specimen from a firm or dense tumor, especially when it is covered

it has penetrated to a depth of 5 to 6 mm., thus freeing the specimen from all surrounding attachments except at the base. Laying aside the punch, the specimen is removed by grasping it with forceps and severing the base with a pointed scalpel or

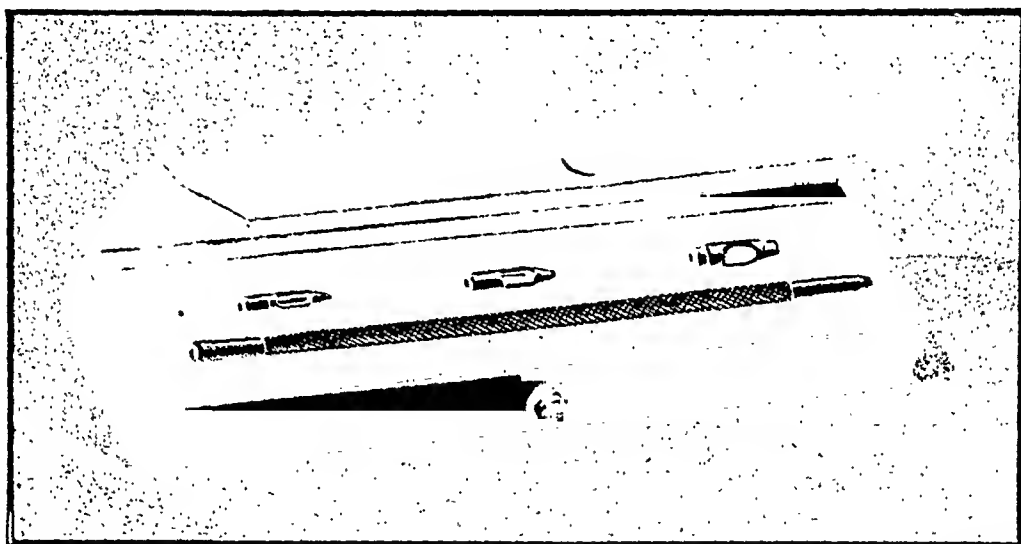


FIG. 1. Biopsy drill punch. Instrument has a single handle to which one of nine variable sized circular sharp punches may be attached ( $1\frac{1}{2}$  to 12 mm.). It cuts cleanly and cores out a tissue specimen of the desired size.

by intact mucous membrane, may traumatize the growth and be painful for the patient when performed with conventional instruments, the most widely used at the present time being some form of biting forceps.

The instrument† which is shown in the accompanying diagram (Fig. 1) consists of a series of variously sized, sharp, circular, detachable punches resembling the ordinary leather punch. The desired size of punch is attached to the handle and after the selected area for biopsy has been infiltrated with an anesthetic solution, the instrument is applied to the tissue and rotated back and forth several times until

biting forceps. The device is of particular value in performing biopsies of non-ulcerated, non-friable tumors in the oral cavity and pharyngeal wall (Fig. 2) in addition to tumors in other accessible areas of the body.

The instrument has a single handle to which one of nine tips may be attached. The available tip sizes are  $1\frac{1}{2}$ , 3,  $4\frac{1}{2}$ , 5, 7, 8, 9, 11 and 12 mm. in diameter.

## SKIN GRAFT DRILL PUNCH

This instrument has been designed to facilitate removal of skin lesions, thereby securing a circular wound with smooth even borders which may be closed from

\* From the Head and Neck Service, Memorial Hospital, New York.

† This instrument is manufactured by and may be purchased from the United Surgical Supplies Co., New York, N. Y.

side-to-side with interrupted stitches. In addition to enabling the operator to core out a skin lesion, the same instrument may be employed if desired to obtain a full thickness skin graft from another part of the body to cover the resultant defect.

The device consists of a special handle with a countertension ring which holds the tissue firmly in place while coring and with five sizes of circular coring tips which measure 7, 10, 12, 15, and 17 mm. in diameter. (Fig. 3.)



FIG. 2. Photograph of a suspected cancer of the tongue, illustrating use of the drill punch in obtaining a tissue specimen for biopsy. The instrument has been placed in the desired area (local anesthesia) and is rotated back and forth several times for a depth of 5 to 6 mm. The specimen is removed by severing the attached base with a pointed scalpel or biting forceps.

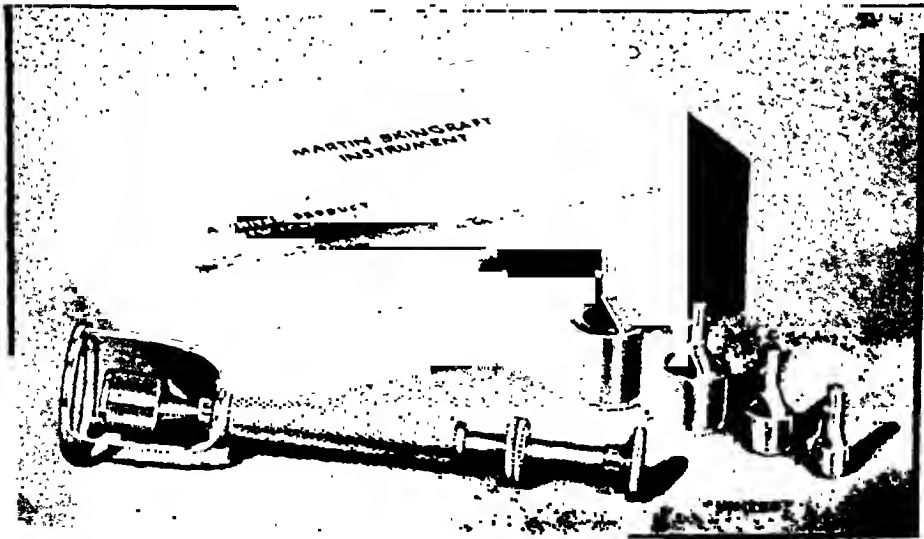


FIG. 3. Skin graft drill punch. An instrument which enables the operator to perform a clean circular excision of a skin lesion. If the defect is to be covered with a full thickness skin graft, the same instrument may be used to core out a graft from another part of the body. The device consists of a special handle with a countertension ring (holds tissue firmly in place while coring) and five sizes of coring tips, measuring 7, 10, 12, 15 and 17 mm. in diameter.

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# Bookshelf Browsing

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## FOUR PIONEER ARCHITECTS IN BONE

KNIGHT, TAYLOR, SAYRE AND DAVIS

EDWARD PODOLSKY, M.D.

BROOKLYN, NEW YORK

FOR the most part the trail in modern bone surgery was blazed by four men: James Knight, Charles Fayette Taylor, Lewis A. Sayre and Henry G. Davis.

Dr. James Knight became interested in bone surgery when he had succeeded in inventing a truss for the treatment of hernia. This he stated, "served as an incentive to the construction of appliances for the rest oration of impaired powers of locomotion in children, laboring under deformities, both congenital and the sequelae of infantile paralysis. Other deformities resulting from constitutional impairment led to a careful study of pathological conditions, such as caries of the spine terminating in spinal or psoas abscess. These latter ailments were carefully considered and a careful regime with proper sanitary regulations and conditions were found the primary requisition of proper treatment. Such conditions, we concluded, were only attainable in the highest degree in a hospital of proper construction. With this impression we introduced the initiatory efforts in our own dwelling." This was in 1863 and from that time on the world began to realize the importance of proper hospital care in the treatment of bone and muscle diseases.

Dr. Knight's hospital was constructed in 1870 and he lived in it with his family and assistants, giving all his time to the treatment of bone disorders. The great majority of cases in those days was tuberculosis of the bones and these patients were required to remain in the hospital for months and even years at a time. "Physi-

cal training and instruction, both religious and secular, were part of the daily life of the patient. Bodily activity was enforced. No child able to hold up its head is ever kept in bed during the day, and all able to walk by pushing a chair before them have thus to exercise for a certain time, and those unable to walk from pain and tenderness are supplied with rolling chairs. Even the most vigorous and robust constitution would inevitably be weakened and brought to a state of etiolation by long continued repose, and in a weak constitution the malady would be proportionately increased."

Dr. Knight was essentially a conservative bone surgeon. He believed most heartily that "by properly enforced hygiene, by regular and nutritious dietary, by mechanical appliances to secure rest for an invaded joint but avoiding every grave surgical interference and by employing every means that contribute to the strength, vitality and comfort of the patient."

The chief claim of Dr. Knight to fame is that he founded the first great bone hospital in the world, The Hospital of New York City for the Relief of the Ruptured and Crippled. This institution has exerted a great deal of influence in the development of bone surgery in this country and throughout the world.

Dr. Henry G. Davis was a contemporary of Dr. Knight and he had similar ideas. He invented a spinal brace for the treatment of serious diseases of the spine; he also invented a hip splint which did away with unnecessary surgery in the treatment of affection of the hip joint. Dr. Davis's work

was little appreciated in his time and his life was one of disappointment at the lack of understanding of the need for his new ideas in bone surgery.

The third and greatest of the modern trail blazers in bone surgery was Dr. F. Fayette Taylor who did some notable pioneering in the treatment of tuberculosis of the bone. His interest in this disease was stimulated by his own experience in the treatment of Pott's disease by exercises designed to check the purposes of deformity of developing muscular resistance.

During the early years of his practice there came under his observation a case of tuberculosis of the spine which was to play a most important rôle in his life. The victim was a little girl. The mother was very insistent; she wanted to know just what the trouble was with her child. Dr. Taylor explained the ailment in a few brief sentences and tried to get away. But the mother was still anxious; she detained the doctor and asked for more information on the nature of the disease. Reluctantly Dr. Taylor explained that her little girl had incipient tuberculosis of the spine, which was at best a rather hopeless ailment.

"How can this be?" the mother persisted, "To all appearances my child is as well as any child. She is not, and she has not been sick as far as I know."

Dr. Taylor replied saying that in spite of her outward appearance she was suffering from a very serious bone disease. The mother listened and after a few minutes said somewhat hopefully: "Well, of course, it can be cured. It has been discovered so early."

Dr. Taylor believed in the policy of telling the truth, no matter how serious the disease. He replied that so far as he knew there was no cure for it.

The mother sat thoughtfully for a few minutes and then asked: "What am I to do?"

Again Dr. Taylor was faced with the unpleasant duty of telling her that as time went on the disease would become worse.

"How long will this be going on?" asked the distracted mother.

"For many years."

"And what will be the result?"

Dr. Taylor described the usual final stages of the disease.

"Do you mean to say," asked the mother, "that my little girl here, who has always been apparently a healthy child, now appears to be so, who is still plump and straight, must go down before my eyes, must suffer, may be confined to bed with paralysis, with discharging abscess through the years, becoming dwarfed and emaciated, distorted and disfigured, and there is nothing which can be done to prevent, or even mitigate such a terrible calamity?"

Dr. Taylor had to reply yes to all these questions. But the overpowering impression that this pitiful entreaty made on him remained for a long time. It made him resolve to attempt to find some means of even giving the slightest aid to this little girl.

After weeks of experimenting Dr. Taylor devised an appliance which he called the spinal assistant. This instrument is one of the greatest achievements of the modern bone surgeon. The spinal assistant is a type of support consisting of steel bars placed on either side of the diseased spine attached above and below to serve as a splint.

Like most great ideas this one came as an inspiration. This is how Dr. Taylor himself describes the incident: "The first real light broke in upon me when one evening just as I passed into the bright light pouring from an ice-cream saloon the thought of the principle of action of a special instrument that would have fixed points and afford perfect protection to the diseased vertebrae struck me. The sensation was most awful. I jumped as if I had received a physical blow, and ran all the way home. The next day I went down town and made the instrument." In this way the first great appliance for the treatment of spinal disease came into existence. Dr. Taylor thereafter devoted his life to the mechanical treatment of diseases of the bone and

attained a reputation as one of the foremost orthopedic surgeons of his time.

The fourth of the great pioneer bone surgeons was Dr. Lewis A. Sayre. He was a well known surgeon as early as 1853. He was one of the founders of Bellevue Medical School and its first professor of orthopedic surgery. Dr. Sayre had always been enchanted with the possibilities of bone surgery.

Dr. Sayre, like Dr. Taylor, had in early life an illuminating experience which was to exert a profound influence. While serving his apprenticeship he had a patient with an abscess about the knee which Dr. Sayre proceeded to open. When he reported the result to his superior the latter called him a "damned blockhead." He had specifically forbidden the opening of so-called cold abscesses about the knee.

"You've killed the man," the professor of surgery growled.

"But," says Dr. Sayre, "he didn't die. He got well, and I never believed anything that any of them told me after that." He had learned to think for himself.

Dr. Sayre invented an operation for reconstructing the diseased hip and restoring it to usefulness. He also invented the plaster jacket for the treatment of certain types of bone deformities, as well as new instruments to make operations on the bone easier and simpler. When Dr. Sayre wrote his great book on bone surgery it was introduced by a quotation from the writings of Dr. Valentine Mott, one of the early great American surgeons. The quotation ran as follows: "It was my happy lot, even at my advancing time of life . . . to witness, also, the dawning as well as the meridian splendor of another new and illustrious era in the healing art; I refer to that beautiful and exact science, *limitedly* denominated *orthopedic surgery*."



# THE BROOKLYN ANATOMICAL AND SURGICAL SOCIETY\*

RUSSELL STORY FOWLER, M.D.

BROOKLYN, NEW YORK

ON March 20, 1878, George Ryerson Fowler and Lewis Stephen Pilcher met with a small group to form The Brooklyn Anatomical and Surgical Club, whose object should be the promotion of the practical study of anatomy and surgery by the maintenance of rooms for the pursuit of such studies, by the formation of a museum, by the accumulation of a library, by lectures and demonstrations and by stated meetings for the discussion of subjects pertaining to that special field.

Lewis S. Pilcher was elected President, George R. Fowler secretary and Zachery T. Emery treasurer. Rooms were secured and fitted up for its use. On September 6, 1879, the Club was incorporated in accordance with the laws of the State of New York, as "The Brooklyn Anatomical and Surgical Society" and was privileged to have a School. The Medical School was incorporated October 17, 1879, so that a member could give instruction in the lecture rooms and laboratories of the Society to persons not members of the Society. Among those who lectured were such famous men as Frank H. Hamilton, Fessenden N. Otis, John C. Dalton, Albert H. Buck and John A. Wyeth. To those familiar with the history of Brooklyn and New York of those years these names will recall much.

It was my privilege as a child to have been taken by my father to the rooms of the Society. I well remember the impression made upon me, the lecture and demonstration room with a black table in the center and three rows of black benches around; the side rooms with shelves with specimens under the windows so that the light shown upon them. It was also my privilege to have known and to

remember some of the original members, particularly Zachery T. Emery, later Health Officer of Brooklyn, Dr. Charles Jewett who brought me into the world and who became Professor of Obstetrics and Gynecology at Long Island College Hospital and Lewis S. Pilcher, first Editor of the *Annals of Surgery* and the longtime associate of my father in the many years in which they both worked as attending surgeons in the Methodist Episcopal Hospital for the up-lift and welfare of not only the surgical profession but of the profession in general and of humanity. I no doubt met the other gentlemen, but the names of those mentioned are those whom I still remember as to their characteristics. All these gentlemen were most kindly to a little boy who clung to his father's hand and who did not altogether like to be left alone in the company of the gruesome skeletons and anatomical preparations in huge glass containers which were everywhere in those dim lighted rooms of the old Brooklyn Surgical and Anatomical Club.

This Society was the forerunner of the *Annals of Surgery*. Dr. W. W. Keene, the noted Philadelphia Surgeon, for many years the Dean of American Surgery, speaking at the dinner celebrating Dr. Lewis Stephen Pilcher's fifty years in practice said of it:

"I never think of Pilcher but that two ideas are correlated with his name. One is Dr. George Ryerson Fowler, his surgical twin and the other is the *Annals of Surgery*, his surgical monument.

"The twins began to collaborate as early as 1878. They founded the Brooklyn Anatomical and Surgical Society with Pilcher as president and Fowler as secretary. In fact, it might almost be said

\* Read before the Section on History of Medicine, of the Medical Society of the County of Kings and Academy of Medicine of Brooklyn, April, 1942.

that they were 'the whole show,' for the twins did most of the work and wrote most of the early papers. When they had enrolled but twenty-five members they boldly launched the *Annals of Anatomy and Surgery*. The first volume consisted of only 102 pages and this represented the accumulation of two whole years, 1878-1879. But values does not depend upon bulk. This little book has two noteworthy papers, one on a complete 'Bifid Sternum' and the other is one of the early papers on a 'Cervical Rib.'

"I have always been glad that I helped them out with two papers in Vols. II and V.

"The next year, 1880, this rapidly growing infant had expanded into one good sized volume and from then on, but not for long, there were two volumes in every year. In January 1884, Vol. IX began bravely with its first number, but chill winter's blast was fatal. With this one gasp it gave up the ghost. As no postmortem was held I cannot give you the bibliographical cause of death.

"But like the fabled Phoenix from its ashes arose the *Annals of Surgery*. Instead of one volume for two years we have had year after year two impressive volumes of nearly 2,000 pages."

William J. Mayo said: "To you physicians of Brooklyn, I need not say how great has been the part played by Doctor Pilcher and also the late Doctor Fowler. The assistants of these men and others like them will dominate the next generation of American surgeons as the students of Billroth and Volkmann dominate the German school of today."

The minutes of these early meetings as well as subsequent ones will repay perusal by the student of surgery whether he be neophyte or master. They exemplify a type of master surgeon which may well be emulated.

The Medical School was incorporated October 17, 1879, under the direction of a board of trustees, consisting of Rev. James M. Buckley, D.D., Hon.

John French, Joseph C. Hoagland, Esq., Hon. Darwin R. James, Hon. Geo. G. Reynolds, L.L.D., Francis S. Street, Esq., James H. Taft, Esq., and Hon. Stewart L. Woodford, some nationally and internationally famous, in addition to the members of the Council of the Society, for the purpose of securing to the Society a legal right to procure and use anatomical material, and to pursue its work of promoting the study of anatomy, surgery and pathology without interruption. In this school, demonstratorships of anatomy, histology, operative surgery and surgical pathology were established.

The first volume of the *Annals of the Anatomical and Surgical Society*, a handsome large octavo volume of 126 pages of closely printed matter bound in muslin, with gilt top and illustrated, privately printed, does not have any mention of who was editor. The second volume was edited by Charles Jewett, associated with E. S. Bunker, G. R. Fowler, L. S. Pilcher and F. W. Rockwell. The third and last volume was edited by Lewis S. Pilcher and George R. Fowler. This volume comprised the transactions of the Society from January to June, 1881, inclusive, and marked a further development of its work. From the modest beginnings of its first year followed the advance made in the second volume. The success of the latter stimulated another advance, the last issue being published January, 1884, later to become, in January, 1885, the *Annals of Surgery*, of which Lewis Stephen Pilcher was editor until his decease many years later and which is still edited by his son James Taft Pilcher.

We have seen how the Brooklyn Anatomical and Surgical Club developed into the Brooklyn Anatomical and Surgical Society and how its transactions became later the *Annals of Surgery*. From the same source sprang the Brooklyn Surgical Society which was organized November 2, 1887, at an informal meeting of:



\*Dr. Fowler, representing St. Mary's Hospital

Dr. Feeley, representing St. Catherine's Hospital

\*Dr. Pilcher, representing M.E. Hospital

\*Dr. Rockwell, representing St. John's Hospital

Dr. Wight, representing L.I. College Hospital

Dr. Thallon

A letter from Dr. Wunderlich (repre-

\* Original incorporators of The Brooklyn Anatomical and Surgical Society.

senting St. Peter's Hospital) warmly endorsing the proposed movement was read. Dr. J. D. Rushmore (City Hospital) and Dr. P. L. Schenck (Kings County Hospital) also sent letters in sympathy with the movement but not committing themselves to take part in it.

After some informal discussion it was resolved on motion of Dr. Fowler to form the Brooklyn Surgical Society, the gentlemen present and Dr. Wunderlich being the founders.



GRANTS for medical research totaling about \$150,000 have been awarded The George Washington University Medical School which this year is operating the largest research program in the history of the 121 year old institution.

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NUMBER TWO

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## Editorial

### OPERATIONS ON THE VAGUS NERVES IN THE TREATMENT OF PEPTIC ULCER

THE majority of surgical operations accomplish their purpose in an obvious manner, in that they remove grossly diseased organs and parts or repair injuries and defects. Examples are the amputation of a gangrenous leg and the repair of a hernia. A much smaller number of procedures are carried out because of more subtle effects which are produced as a result of anatomically small but physiologically potent structural alterations in endocrine gland and nervous tissue. The removal of a small parathyroid adenoma may stop a demineralizing process which is weakening many areas of the skeleton. The removal of a thyroid gland, an islet cell adenoma of the pancreas or an adrenal tumor is likely to change the whole complexion of things for the patient. The cutting of the white fibers in the frontal lobes has resulted in favorable personality changes; the pain of malignant disease in a remote area of the body has been relieved by a small properly placed incision in the medulla. There are circumstances which make it advisable to paralyze certain muscles by depriving them of nerve supply. A diseased lung is put at rest by crushing the phrenic nerve to its half of the diaphragm. The obturator nerve is cut to prevent troublesome adductor contrac-

tions in the spastic child. Sympathetic nerves and ganglia are removed to paralyze the smooth muscle in arterioles and diminish peripheral resistance, thus lowering blood pressure.

Until recently, there has been no good example of the surgical interruption of the nerve control of a secretory organ in order to achieve a therapeutic result. Section of the vagus nerves to the stomach in patients with peptic ulcer represents the prime example of that type of surgical approach. It is easy to think of the lesion as being due to disturbed physiology. There is an answer provided to the question "Why doesn't the stomach digest itself"? The answer: "It does a little, sometimes—and you have an ulcer." The hyperacidity of gastric juice in ulcer patients has been known for a long time. Dragstedt and his co-workers have shown that the night and resting secretions of gastric juice in such patients is increased over that of non-ulcer patients. They have stated that this excessive secretion appears to be due chiefly to an abnormally great secretory tonus in the vagus nerves and is reduced to normal values by complete vagus section.

It would appear advisable to evaluate the new physiological surgical treatment of ulcers as thoroughly and as rapidly as

possible. Several groups are doing just this. Of Dragstedt's patients which number more than one hundred seventy many have been followed for three or four years. As a result of this experience he is still enthusiastic about the procedure. Francis Moore and his co-workers have made careful observations on forty patients treated by vagus resection over a two year period. Their results have been distinctly encouraging. Grimson and his group have reported on twenty-five patients; they have emphasized some of the undesirable symptoms occurring in the immediate post-operative period, the most important of which relates to the early hypomotility.

An early solution to the problem of the ultimate value of section of the vagus nerves to the stomach has not been promoted by the giving of undue attention to minor differences in technic and terminology. In the first place it should be crystal clear that a subtotal resection of the stomach, to which a subdiaphragmatic section of the vagi has been added, should be included in category apart from that of pure vagus section. At most, a series of such patients would be of value only to indicate the prophylactic value of vagotomy in the prevention of jejunal or marginal ulcer. On the other hand, the nerve operation was never calculated to open up a stenosed pylorus. Resection or by-passing surgical procedures are plainly indicated.

Originally, Dragstedt used the trans-thoracic approach to the vagi; recently,

he has favored the transabdominal route. It appears that a clean section can usually be accomplished either way. It is probable that as long as vagi are cut, the thoracic surgeons will attack them through the thorax and the "general and abdominal" surgeons will reach them by a transperitoneal operation. At the present time there is no proof that it makes any difference what is done with the ends of the nerves after they are cut. They may be stripped upward and downward and resected, the proximal ends can be transplanted out of the mediastinum or non-absorbable caps can be placed over them. The important thing seems to be to cut them—all of them.

It has been suggested that these nerves which have been sectioned for ulcers should not be called vagus nerves but rather, "gastric nerves." It remains to be seen if devotees of Gray's *Anatomy*, most writers on the subject of vagus resection and countless other surgeons who have always called these structures vagus nerves, can be won over to a different terminology.

Finally, it is occasionally stated that vagotomy for ulcers is not new, with some note of implication that the operation has been tried and found wanting. In answer to this, one could safely reply that the operation has been carried out with much greater frequency and thoroughness since Dragstedt's paper on the subject in 1943.

CONRAD R. LAM, M.D.



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# Original Articles

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## FAT NECROSIS OF THE FEMALE BREAST\*

### REPORT OF ONE HUNDRED TEN CASES

FRANK E. ADAIR, M.D. AND JEAN THOMPSON MUNZER, M.D.

NEW YORK, NEW YORK

THIS is the first communication on fat necrosis of the female breast to come from the Breast Clinic of the Memorial Hospital since 1924. In May, 1920, Lee and Adair,<sup>1</sup> presented the original report on this condition before the American Surgical Association, describing the clinical, operative and pathological findings in two cases, and establishing fat necrosis of the breast as a definite clinical entity. Two further reports, in 1921<sup>2</sup> and 1924,<sup>3</sup> were based on an additional seven cases which had been seen at the Memorial Hospital, and included the findings in eleven other cases which had been contributed in personal communications to the authors or which had appeared in the literature. As our experience broadened from our first two cases to the twenty discussed in our third paper, we found it necessary to modify several of our original conclusions. We still, however, retained the name "Traumatic Fat Necrosis," and continued to emphasize the striking clinical similarity to cancer, with the consequent difficulties in differential diagnosis, both clinically and on gross examination of tissue excised in the operating room.

Between 1924 and 1930 a number of isolated cases were reported in the literature, and in April, 1930, Hadfield<sup>4</sup> presented a summary of all the cases which had been published up to that time, including three of his own, a review of the twenty cases which we had previously

reported and twenty-two other cases collected from the literature. On the basis of these forty-five cases, Hadfield drew certain conclusions, namely, that the importance of the traumatic factor had been overstated by Lee and Adair in the three papers from the Memorial Hospital, and that not enough stress had been laid on the fact that in quite a fair percentage of cases, the clinical resemblance to cancer is superficial and is unlikely to lead to excision.

The only other large group of cases to be reported appeared in a paper by Menville<sup>5</sup> in 1935. This paper is based on a review of three thousand breast tumors collected in the Johns Hopkins surgical laboratory, of which Menville classifies fifty-eight as fatty tissue tumors. Twenty-four of these were lipomas; twenty-five were instances of fat necrosis, and the remaining nine, which Menville describes as secondary xanthomatous degeneration, probably, as he himself suggests, represent a secondary change in a pre-existing fat necrosis. Menville was interested chiefly in the pathology and pathogenesis of these conditions, and in the interrelationship existing between the lipomas and the cases of fat necrosis.

Dunphy<sup>6</sup> contributed an excellent paper in January, 1939, in which he again called attention to the fact that fat necrosis in the breast might present the clinical aspects of a malignant neoplasm and thus lead to ill advised surgical treatment. In the

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sixteen cases he presented of fat necrosis in various parts of the body, two were of fat necrosis in the breast, and two showed nodules in radical mastectomy scars. In all four of these cases the diagnosis of carcinoma was made, and the first two patients were subjected to radical mastectomy. Dunphy went on to discuss fat necrosis in other sites as well as in the breast, and included a review of the pathology of the condition.

This paper is offered in the hope that it will help to clarify the confusing clinical picture which fat necrosis may present when it appears in the female breast. In the large number of patients which we have had the opportunity to study, we have seen fat necrosis in different forms and different stages simulating many conditions; we hope that what we have learned may be of use to the clinician who comes upon the condition less frequently.

Between January 1, 1924, and January 1, 1946, the diagnosis of fat necrosis has been made on 136 patients admitted to the Breast Service of the Memorial Hospital. In one hundred ten of these cases, the final diagnosis rested on the examination of the involved tissue in the pathological laboratory, and it is on the findings in these one hundred ten cases of proven fat necrosis that this paper is based.

*Incidence.* These one hundred ten cases make up 0.59 per cent of the total (18,680) cases admitted to the Breast Service between January 1, 1924, and January 1, 1946, and constitute 2.75 per cent of all benign tumors during this period, with an incidence in comparison with primary operable carcinoma of the breast of 2.23 per cent. If the twenty-six cases in which we have no pathological confirmation of the diagnosis, but in which the history, physical findings and clinical course all support the diagnosis, be included, these percentages rise to 0.73 per cent of the total, 3.40 per cent of the benign tumors, and an incidence of 2.76 per cent in comparison with primary operable carcinoma. Those twenty-six patients in whom a

provisional diagnosis of fat necrosis was made on the first clinic visit but who did not return for follow-up are not considered in this paper.

*Age.* The youngest patient in our series was fourteen, the oldest eighty. The peak was met in the fifth decade, with the next greatest frequency equally divided between the fourth and sixth decades. This corroborates our former observation and that of others that fat necrosis is primarily a disease of middle life, occurring most often in the so-called cancer decades. It does, however, show an age range not seen in our earlier cases.

*Weight.* Our weight range was from 101 to 255 pounds, with an average weight of 157 pounds. This agrees with former findings of obesity but to a lesser extent. Although forty-five of the 110 patients were obese, weighing 150 pounds or more, with twelve weighing over 200 pounds, in thirty-eight of the women the weight was below 150 pounds with the breasts described as "moderate size" or "small." Twenty-six patients were definitely slender. In twenty-two cases we have no information either as to body weight or as to the conformation of the breasts, and in the remaining five the breasts were "large and pendulous" although the body weight was not above average.

*Etiology.* A detailed mammary history was taken from each of the 110 women in this series. In sixty-two of them there was no history of trauma, no previous operative procedure, no infection and no difficulty with lactation, just the accidental discovery of a mass in the breast from two days to eight years before the first appearance at the clinic. In two additional cases, there was no known factor predisposing the breast, but these two women presented the clinical picture of relapsing febrile nodular non-suppurative panniculitis. Four women gave a history of infection; two had had superficial abscesses of the skin of the breast within a few months of the development of the mass; the other two had had incision and drainage of deep-

seated abscesses, one postpartum many years before. One patient had had x-ray therapy for chronic cystic mastitis which had been heavy enough to produce chronic progressive skin changes. Of the remaining forty-one cases—the only ones to whom the term traumatic could be held to apply—twelve had had a previous operation on the breast for some other condition, falling thereby into an etiological subgroup under “surgical trauma.” Three had had hypodermoclysis beneath the breasts. In twenty-six cases there had been a single episode of fairly violent physical trauma, sufficiently severe in twenty-one cases to produce ecchymosis, to the site at which a lump developed within a highly variable length of time, from “immediately” to seventeen years. Despite a few (six) cases of many years’ interval, the majority (thirty-five) showed the development of a mass within one year of the injury.

It is of interest to note that in every case in which the patient gave any history of trauma the injury was a single, well remembered episode, adequate, as described to the physician, to produce considerable tissue damage. This contrasts with the vague history of a “blow on the breast,” or “irritation from a corset,” so often vouchsafed by the cancer patient.

Careful review of our cases fails to show any consistent difference in clinical findings between the cases in which there has been a traumatic etiology and those in which there has not. There is no significant difference in the average weight of the two groups; such slight difference as does exist disagrees with the findings of previous observers, for the patients who developed their masses without preceding trauma average 155 pounds in comparison with the 160 pound average of the group with a positive history of trauma. It is therefore certainly not reasonable to presuppose an element of vascular stasis from the “heavy, pendulous breasts” in the non-traumatic group as a form of pseudotrauma in order to classify them all under the heading of “Traumatic Fat Necrosis.” It would be

preferable, as has already been suggested by several writers, simply to dissociate the limiting adjective “traumatic” from the name of this condition.

It would seem logical to designate this disease entity simply by the name, “fat necrosis of the breast,” since pathologically the tissue changes are identical with those which may take place elsewhere in the body, namely, in the omentum, in a lipoma or in the subcutaneous fat. The clinical importance of the condition of which we are writing is derived chiefly from its location in an organ especially susceptible to tumor formation of many kinds, including cancer, with its necessity for prompt and radical surgery.

Although fat necrosis has been produced experimentally with success for a good many years,<sup>7</sup> and although we know a good deal about the mechanism of its production in laboratory animals, the etiology in man is not known. Unquestionably trauma is one predisposing factor, as indicated by the 40 per cent incidence in the forty-five cases reviewed by Hadfield in 1930, and by the 37 per cent incidence of trauma in this series of 110 cases. Apparently obesity is also a factor though not as important as one as previously thought. In our present series, we have no evidence that chronic infection plays a rôle, since these patients showed a somewhat less than average incidence of bad teeth, infected tonsils, gallbladder or pelvic disease. Two of the patients presented the syndrome of Weber-Christian’s disease, and in their cases the etiology of the lesions in the breast would presumably be the same as that of similar lesions elsewhere. In the other 108 patients, the mass in the breast or in the mastectomy scar, as it occurred in three, was apparently an entirely localized phenomenon. These patients showed no similarity of constitutional type nor any associated lesions to suggest any widespread metabolic derangement. Of the twenty-three patients who have been followed for five years or more, not one has shown a repetition of the process.

*Pathology.* The pathology of this condition has been fully described by Ewing in our original article and by other writers, and we shall not enter into any further discussion of it here. We should, however, like to recall Dr. Ewing's<sup>1</sup> able description of the confusing similarity between the gross and sometimes even the microscopic features of fat necrosis and carcinoma. It is true that at certain stages in the life history of fat necrosis the gross diagnosis can be made with certainty by the general surgeon; this fact, however, should not lead to a dangerous overconfidence. Fat necrosis may assume a variety of appearances; the surgeon should always bear in mind that the differentiation from carcinoma may be a difficult one even for the experienced tumor pathologist. Clinically it is as important to the patient that the breast containing only an area of fat necrosis be preserved as that the entire breast which has contained a carcinoma be removed. There is no room in either case for uncertainty in the diagnosis or correct surgical procedure.

*Clinical Signs.* In our entire series of 110 cases, the patient herself found "a lump" in the breast and came to the Memorial Hospital either directly or through referral by her local physician because of the mass. In only thirty-eight cases was there any associated pain, and in eighteen of these the pain immediately followed trauma, the mass persisting after all pain had subsided. In only eight cases was the mass first noticed because of pain. The most consistent physical finding was that of skin attachment. This was found in sixty-four cases, or 58 per cent. This is of particular interest, of course, since attachment to skin is one of the leading signs in the differential diagnosis of cancer from other tumors of the breast. Attachment to the deeper tissues was found in only nine cases, and elevation or retraction of the nipple was noted in only fourteen. Ecchymosis was observed in twenty-four cases, or 22 per cent; twenty-one of these twenty-four patients gave a definite history

of trauma. Two patients without any history of trauma, however, showed quite marked ecchymosis, and one of the cases of panniculitis had a bluish discoloration of the overlying skin. Ten other women showed definite redness of the skin, two in the traumatic and eight in the non-traumatic group. In thirty-one women, or 29 per cent, the axillary nodes showed sufficient enlargement to warrant description, but in only nine cases were these thought to be metastatic. This is, however, a higher incidence of suspicious appearing axillary nodes than has been previously described. In size, the masses varied from  $\frac{1}{2}$  cm. to 10 cm. in the greatest diameter; and in consistency they were variously described as hard, firm, rubbery, elastic, cystic and soft.

*Provisional Diagnosis.* The provisional diagnosis was made in each case by a specialist on the Breast Service. The variety of these diagnoses illustrates better than anything else the wide range of forms fat necrosis may assume.

In seventeen cases, fat necrosis was correctly diagnosed at the first visit to the clinic. Twelve of these patients gave a history of accidental trauma to the breast, and three others had had operative procedures done. The diagnosis of fat necrosis was made on only two patients in the absence of a traumatic history. In six other cases, fat necrosis was given as a second possibility; of these, five had a history of trauma and one did not. This means that only 15.5 per cent of the 110 cases were correctly diagnosed before aspiration or excision, in spite of a 37 per cent incidence of a positive traumatic history. Inclusion of those cases in which fat necrosis was considered as a second possibility raises this percentage only to 21 per cent.

Cancer was diagnosed in thirty cases, twenty-six times as primary operable carcinoma, three times as recurrence in scar and once as metastatic disease on the chest wall after a radical mastectomy. The diagnosis of cancer was made in five pa-

tients even though they gave a history of trauma and in five other patients who had had previous breast surgery. Cancer was considered the second most likely diagnosis in an additional nineteen cases, eight of whom had a history of trauma and one of whom had had breast surgery. In our 110 cases then, forty-nine or 44.5 per cent resembled cancer sufficiently to necessitate a differential diagnosis; the remaining sixty-one resembled various benign conditions.

Among the benign diagnoses we find fibroadenoma occurring fifteen times, chronic mastitis fifteen times, cyst sixteen times, sebaceous cyst three times, abscess three times, neurofibroma twice, and galactoceles, lipoma, cystosarcoma, duct papilloma, stasis and cutaneous neurofibromatosis once each. In three cases no diagnosis was suggested.

*Operative Procedures.* In twenty-two cases, aspiration biopsy alone was done. In twenty-seven cases, there was aspiration followed by local excision. Local excision without preceding aspiration was performed in fifty-seven cases. In one woman with enormous breasts, bilateral simple mastectomy was done for symptomatic relief. In one other case, bilateral simple mastectomy was done because of the extent of disease in both breasts. We performed one simple mastectomy with axillary dissection, and one revision of a radical mastectomy.

It is to be observed that in these 110 cases, only two unnecessarily radical operations were done, in marked contrast to our own former experience and that of others (27 per cent of the forty-five cases reviewed by Hadfield, 20 per cent of Menville's twenty-five cases, had radical mastectomies). Of these two, one was the simple mastectomy with axillary dissection under novocain on an eighty year old woman in whom we were mistaken in our clinical diagnosis of cancer; the other was the revision of a radical mastectomy on a patient in whom we erroneously diagnosed recurrence in scar.

Although we did not rely on an aspiration

biopsy alone in any case if the clinical course did not show progressive resolution of the mass, still in our hands this diagnostic measure proved a valuable aid. In all cases in which local excision followed aspiration because of persistence of the mass, the local excision confirmed the diagnosis made on aspiration biopsy.

*Course.* Of the 110 patients in this series, seventy-two, or 65 per cent, were followed for a period of six months or more. Fifty-five cases were seen over a period of one year or more, and twenty-three were followed for five years. With the exception of one woman who was suffering from Weber-Christian disease, and one who had progressive skin changes following x-ray therapy and went on to develop a carcinoma sixteen years after local excision of an area of fat necrosis, all the women were free of any evidence of disease in either breast at the time of their last clinic visit. In twenty of the twenty-two patients who had aspiration biopsy without further surgery, there was spontaneous resolution of the mass within a maximum period of three months. The remaining two patients of this group failed their clinic appointments before complete resolution of the mass had occurred. We doubt if a calcified area of fat necrosis would spontaneously disappear.

#### CASE REPORTS

We are presenting ten of the 110 cases in more detailed form in order to illustrate some of the points we have discussed.

The first case is chosen as a typical case of fat necrosis simulating a benign condition in both history and clinical findings:

S. E., a twenty-two year old unmarried clerk, was admitted to the Memorial Hospital on April 13, 1932, complaining of a lump in the left breast. The patient had accidentally discovered a small lump in the left breast one year before admission. This gave no trouble until four days before she applied at the clinic, at which time she noticed slight pain in this breast for the first time. The patient believed the mass had grown very slightly in



size during the past year. There was no history of any injury to either breast nor of any previous symptoms referable to the breasts. There had been no history of illness and her general health was good.

Physical examination showed the patient to be a well developed young woman, moderately overweight (weight 157 pounds).

The breasts were rather large, but in proportion to the patient's moderate obesity. In the upper, outer quadrant of the left breast near the periphery there was a hard, irregular, flattened mass about  $2\frac{1}{2}$  by 2 by  $1\frac{1}{2}$  cm. This mass was located subcutaneously and showed slight but definite attachment to the skin. The right breast and both axillae were normal.

Provisional diagnosis: (1) Fibroadenoma; (2) chronic mastitis.

Local excision was performed on May 4, 1932.

A large area of breast tissue was examined by the pathologist. In this tissue were several nodules of yellow fat necrosis with calcification. On section it revealed calcified inflammatory fat necrosis.

There were no postoperative complications; the incision healed by primary union. The patient was followed regularly in clinic until January 4, 1937, when she was discharged with no evidence of disease in either breast.

The second case is selected as a typical case of fat necrosis simulating a malignant condition, but with a definite history of trauma which made the correct diagnosis possible:

M. D., a fifty year old unmarried seamstress, was admitted to the Memorial Hospital on June 15, 1933, complaining of a lump in the right breast. The patient had been struck by an automobile eight months before admission. There was an extensive old laceration of the right upper arm and a severe contusion of the outer portion of the right breast, which remained black and blue for several months. A hard mass developed within the traumatized part of the right breast within the first few hours after the accident, and the patient had noticed no change in this mass during the eight months preceding admission. There was no history of any other difficulty with either breast. Her health otherwise had been good generally.

Physical examination revealed the patient to

be a moderately obese, middle-aged woman in apparently good general health. She was short, weighing 150 pounds, and had gained 20 pounds since the accident eight months ago.

The breasts were moderately large and pendulous. The right breast showed a diffuse duskeness in its outer half. In the upper outer quadrant, 4 cm. from the nipple, there was a very hard mass, 5 to 6 cm. in diameter, which showed attachment to the skin. The axilla and left breast were normal.

Provisional diagnosis: One of us made the comment, "If it had not been for the history pointing to traumatic fat necrosis, I should have made the diagnosis of carcinoma."

Aspiration biopsy was performed on August 8, 1934, and the pathological evidence supported the diagnosis of traumatic fat necrosis.

This patient was followed in clinic until July 3, 1939, after which date she consistently failed her appointments. When last seen, on July 3, 1939, there was still "some induration in the outer quadrant of the right breast, but definitely less than previously described."

The third case is presented because it shows fat necrosis simulating a malignant process without any history of trauma. This case was misdiagnosed, aspiration biopsy was done, and the patient was subjected to an unnecessarily radical operation because of our desire to shorten a long operation in an eighty year old patient.

K. G., an eighty year old married woman, was admitted to the Memorial Hospital on November 1, 1936, complaining of a painless lump in the right breast. She had accidentally discovered a lump in the right breast one week before admission. There was no history of injury to the breast. The patient had never had any difficulty with either breast. There was one uneventful lactation fifty-five years before.

The patient had had hypertension for the past fifteen years. Physical examination showed the patient to be a thin little woman in fairly good condition for her age; her blood pressure was 190/100; heart sounds were of good quality with no murmurs and the lungs were clear.

The breasts were small and flabby. In the right breast at 12 o'clock, approximately 10 cm. above the nipple, there was a hard, irregular mass about 2 cm. in diameter. There was

definite skin attachment. There were several hard nodes in the right axilla 1 to 1 to  $1\frac{1}{2}$  cm. in diameter. The left breast and axilla were normal.

Provisional diagnosis: Carcinoma of the right breast with metastasis to axillary nodes.

A right simple mastectomy with removal of the lower axillary nodes was performed on November 2, 1936. One per cent novocain anesthesia was used.

The pathological specimen consisted of an atrophic breast with almost no recognizable mammary tissue, together with a portion of the proximal axillary fat. In one area (marked by operator) was a small cystic area in fat. There was no recognizable wall. This area was a few mm. in diameter, irregular, and with some fairly fresh looking blood. The surrounding fat was a trifle firm. In it was one minute poorly outlined greyish area. The balance of fat was light yellow, greasy in texture, though without opaque areas. The axillary fat contained two nodes both consisting of a cortical ring of lymphoid tissue and "a fatty hilum. The pathologist's report stated: "Inflammatory fat necrosis; nodes clear."

The patient made an uneventful recovery from her operation. She was last seen on June 24, 1938, at which time she showed no evidence of disease in the left breast or in the right chest wall.

The fourth case is given because carcinoma with metastasis to very large axillary nodes was considered the probable diagnosis in spite of a history of trauma, with pain and ecchymosis preceding the appearance of the mass. The repeated use of aspiration biopsy saved the patient from unnecessary surgery:

S. S., a forty-eight year old unmarried dressmaker, was admitted to the Memorial Hospital on December 31, 1941, complaining of tenderness, discoloration and mass in the left breast.

Two weeks before admission the patient slipped in her bathtub and fell, striking her left breast against the faucet. There was immediate severe pain in the breast, which the patient alleviated by the application of cold towels. The traumatized area became black and blue within a few hours, and this discoloration became more intense and greater in extent during the following week. The discoloration had

gradually faded; the breast was still tender, but no longer spontaneously painful. She felt that the breast was "lumpy" at the site of injury. The patient was "positive" that there was nothing abnormal in the breast before the fall. She gave no history of serious illness and had gone through an uneventful menopause four years before.

Physical examination revealed the patient to be a middle-aged woman in apparently good general health. Her weight was average.

The breasts were moderate, equal in size and symmetrical. There was a diffuse area of greenish-yellow discoloration extending over an area 7 by 8 cm. in the upper half of the left breast. Underlying this area of ecchymosis was a poorly defined, irregular thickening, with two small nodules palpable within the thickened area, each measuring about 1 cm. in diameter, and both showing definite attachment to skin. In the left axilla two enlarged lymph nodes were palpable, measuring from 2 to  $2\frac{1}{2}$  cm. in diameter, freely movable, not attached to skin, but hard in consistency. The right breast and axilla were normal.

Provisional diagnosis: The history of injury and the ecchymosis naturally suggested the diagnosis of traumatic fat necrosis. It was believed, however, that the axillary nodes were clinically metastatic carcinoma. Diagnosis was deferred pending report on aspiration biopsy of one of the axillary nodes. On December 31, 1941, aspiration of an axillary node was reported "fat only" on the smear, and "lymphoid tissue only" on the clot. On January 5, 1942, aspiration biopsy was done on the thickened area in the breast. This was reported "fat only" on both smear and clot.

On January 19, 1942, the patient was taken to the operating room with the provisional diagnosis of probable carcinoma of the breast with metastasis to axillary nodes. A local excision of the larger nodule in the left breast was done, and frozen section made from this. Report of the frozen section was fat necrosis. The larger of the two axillary nodes was also aspirated in the operating room, and this material sent down for examination along with the excised breast tissue. When both were reported benign, the incision in the breast was closed.

The pathological specimen consisted of a locally excised mass of breast tissue approximately 8 by 5 by 4 cm. A small skin ellipse

was attached. On section there was an area approximately 1 cm. in diameter situated approximately 1 cm. below the skin surface. It appeared essentially as a liquefied area of fat, somewhat dark and rather soft in its central portion and having almost the appearance of a cystic structure. There were small areas of breast tissue scattered through the mass but no particular changes were noted. The pathological report stated: fat necrosis. Aspiration biopsy of the axillary node revealed lymphoid tissue.

The fifth case is one of fat necrosis following trauma in which the correct diagnosis seemed apparent:

R. J., a fifty-nine year old married housewife, was admitted to the Memorial Hospital on May 29, 1936, complaining of a lump in the left breast. She had been in an automobile accident two weeks before admission, at which time she was thrown violently against the seat in front, striking her left breast. That night she felt a burning soreness throughout the entire left breast and stated that it became black and blue and felt hot. She applied hot compresses with some relief. She had been aware of a tender mass in the breast since "shortly" after the accident. Twenty-five years before admission, a tumor of two years' duration was removed from the left breast, and the patient was told that this was benign. There was a history of two uneventful eighteen-month periods of lactation, twenty-four and nineteen years ago. She suffered with serious illness in the past, but experienced an uneventful menopause seventeen years before.

Physical examination showed the patient to be a healthy appearing woman of average weight (135 pounds); her blood pressure was 180/100; heart sounds were of good quality with no murmurs.

The breasts were of moderate size, the left slightly smaller than the right. There was a healed scar running horizontally in the upper outer quadrant of the left breast. There was a superficial ecchymosis involving the upper portion mainly but including the areola. Underlying this area of ecchymosis just beyond the areolar border, was a rather soft tumor measuring  $2\frac{1}{2}$  by 2 by 1 cm. There was definite skin attachment.

Provisional diagnosis: Traumatic fat necrosis. Aspiration biopsy was performed on May 29,

1936, and the pathologist reported inflammatory fat necrosis.

On June 29, 1936, one month after aspiration, the mass was no longer palpable. The patient was discharged from the clinic three and a half years later with no evidence of disease in either breast.

The sixth case shows the bilateral development of fat necrosis in breasts in which vascular stasis may have played an important rôle:

L. F., a twenty-two year old unmarried salesgirl was admitted to the Memorial Hospital on July 26, 1934, complaining of a painless lump in the right breast. The patient had been markedly overweight as long as she could remember. For the past three years her breasts had been growing progressively larger. The patient's mother was very obese and had very large breasts. Four months ago the patient accidentally discovered a lump in her right breast; this had produced no symptoms. There was no history of trauma or infection. Her general history was negative except for a lifelong obesity. Menarche took place at eleven, and her menstrual history was entirely normal.

The patient was a tremendously obese young woman, weighing 240 pounds. Fat deposits were chiefly in the breasts, abdomen and hips; the wrists and ankles were slim. There were no remarkable physical findings except the obesity, and a soft systolic murmur at the apex of the heart, with frequent extrasystoles. There were no endocrine stigmata beyond the unusual weight distribution.

The breasts were enormous, resting on the patient's thighs when she sat. The breast tissue itself had collected into irregular, nodular masses in the lower portions. The upper part of the breasts consisted of a mere band of skin and fatty tissue. The lower part showed discoloration and evidence of vascular stasis. In the lower, inner quadrant of the right breast was an irregular, lobulated mass 10 cm. in diameter. It was movable and not adherent to the skin. The left breast also contained numerous thickened areas, but there was no tumor so definite as that in the right. There was no axillary adenopathy.

Provisional diagnosis: Fibroadenoma or cystosarcoma of the right breast; bilateral virginal hypertrophy of breasts.

A bilateral simple mastectomy with plastic formation of pseudobreast on each side was performed by August 8, 1934.

The specimens consisted of a right and left breast, the right weighing  $4\frac{1}{2}$  pounds, the left  $5\frac{3}{4}$  pounds, removed by partial mastectomy. The cut section revealed no normal breast tissue except a small amount beneath the areola which consisted of ducts only. On sectioning the breasts, diffuse areas of lobulated fat were found throughout, rather firm in some areas, probably due to the fibrous "capsule" of the lobule. On section the specimens revealed diffuse lipomatosis with multiple areas of fat necrosis.

Gross diagnosis: Fat necrosis, with some xanthomatous changes.

A clinic note on March 25, 1935, reports: Breast tissue is soft; breasts are completely healed; the right breast is slightly larger; there is no tendency to increase in length.

The seventh case is one of fat necrosis with associated echymosis and pain, occurring in a thin woman without any history of trauma.

E. O., a forty-one year old married machine operator, was admitted to the Memorial Hospital on March 19, 1943, complaining of a tender lump in the left breast. When she awakened in the morning two days previously, the patient noticed that her left breast was lumpy and sore. There was no history of injury and she had had no previous trouble with either breast. The patient had a normal pregnancy thirteen years before, but did not nurse the baby due to inadequate milk supply. She had had no serious illness; her general health was fairly good, but she was not vigorous. Physical examination revealed the patient to be a pale, undernourished woman looking several years older than her stated age. She weighed 101 pounds; her teeth were carious with moderate recession of the gums; there were no other positive physical findings.

The breasts were small, equal and rather pendulous. The skin of the left breast was yellowish, giving the appearance of a regressing hematoma of the breast with a central area at 11:30 o'clock moderately hemorrhagic. In this area there was a slight fusiform swelling in fat, and a visible cirroid swelling on the axis of 12 o'clock, 2 cm. beyond the areolar border.

No axillary nodes were present. The area on transillumination was definitely opaque.

Provisional diagnosis: Duct papilloma with stasis and spontaneous rupture of a blood vessel.

Aspiration biopsy was performed on March 22, 1943. A few connective tissue cells only were present. Local excision was carried out on April 13, 1943.

The specimen consisted of an elliptical portion of skin measuring 6 by  $3\frac{1}{2}$  cm., together with a small portion of underlying breast tissue. Just beneath the skin was a small cystic area  $1\frac{1}{2}$  cm. in diameter. It was filled with chocolate brown semi-solid fluid. The adjoining breast tissue appeared normal. On section fat necrosis with foreign body reaction and hemorrhage with secondary cystic degeneration was noted.

No postoperative complications occurred. The patient was last seen in the clinic on April 27, 1944, at which time there was no evidence of disease in either breast.

The eighth case (Case 104) is of fat necrosis in a girl of fifteen, with nothing in the history or physical findings to suggest the correct diagnosis.

R. P., a fifteen year old high school student, was admitted to the Memorial Hospital on January 18, 1945, complaining of a lump in the left breast. She had noticed a slight pain in the left breast two months before admission. She examined the painful area and found a small lump. She did not believe the lump had changed in size since first noticed. Only slight tenderness persisted at the time of admission. There was no history of injury to either breast and no previous symptoms referable to either breast. This young girl had been in good health all her life, with no history of serious illness. Menstrual periods had been regular since onset two years previously. Physical examination revealed a normally developed young girl, weighing 125 pounds. She appeared to be in very good general health.

The breasts were of moderate size, symmetrical and erect. The nipples and areolae showed a normal virginal appearance. On three o'clock axis in the left breast, at the lateral border of the areola was a 1 by 1 by 1 cm. mass, discrete, freely movable, slightly tender and of elastic consistency. There was no evidence

of attachment to skin. The right breast and both axillae were normal.

Provisional diagnosis: Fibroadenoma.

Local excision was performed on January 19, 1945. The specimen consisted of an irregular, rather firm mass of translucent breast tissue measuring 2 cm. in its greatest diameter. In one area a small rounded opaque yellowish focus was seen. The section revealed fat necrosis.

The ninth case is presented to illustrate the deceptive appearance of fat necrosis occurring in a mastectomy scar. This was one of three similar cases in our series. Such lesions are not rare following radical mastectomy.

N. F., a fifty-seven year old unmarried teacher, was admitted to the Memorial Hospital on August 1, 1939, complaining of three hard lumps in a mastectomy scar. In October, 1937, the patient had a left radical mastectomy for cancer. She did not have postoperative x-ray therapy. In June, 1938, she had a right simple mastectomy performed for chronic cystic mastitis. Shortly after this second operation, she noticed a small tender firm mass in the lower portion of the radical mastectomy scar. This increased slightly in size, and two other similar nodules appeared in the two months preceding admission. The patient had had no serious illness or operation except those performed on the breasts. Her general health was good. Physical examination revealed a fairly well developed and well nourished middle-aged woman in apparently good general health. Her blood pressure was 130/92.

Both breasts had been removed, the right by a simple, the left by a radical mastectomy. In the lower third of the left mastectomy scar was a hard, non-tender mass, just under 1 cm. in diameter, adherent to skin. There was a similar, slightly smaller mass in the axillary portion of the scar, and a third hard nodule in the upper left arm, 2 cm. away from the incision. There was no evidence of disease in either axilla, supraclavicular or infraclavicular areas.

Provisional diagnosis: Recurrent carcinoma in scar.

Local excision was performed on August 2, 1939.

Pathological specimens consisted of three

areas: Area No. 1 was a skin ellipse 6 by 4 cm. with 2 cm. of underlying fat tissue in the center of which was an irregular, non-circumscribed, discoid mass, yellowish-white in color, with peripheral radiating strands and typical chalk streaks of carcinoma. No description was given of areas Nos. 2 and 3. On section of areas 1, 2 and 3, there was fat necrosis.

The tenth case is that of relapsing febrile, nodular, non-suppurative panniculitis.

L. K., a thirty-six year old married woman, was admitted to Memorial Hospital on March 23, 1937, complaining of swelling and lumps in both breasts. Two months before admission the patient developed the first lump in her left breast. There was associated redness and swelling of the surrounding skin but no pain. Two weeks following this first lump, a similar mass appeared in the right breast, starting as a swollen soft lesion, covered with reddened skin, and gradually subsiding to a discrete hard nodule. Two subsequent masses appeared in the left breast, running an identical course. There was no history of trauma to the breasts. There had been one period of several months' lactation, and a two-week period with the second child, terminated because of "caked breasts." She had suffered with polyarthritis with chills and fever six years before. She also gave a history of painless subcutaneous nodules two years before, distributed over entire body, but especially on the lower extremities.

The patient was an obese young woman, not appearing ill at the time of examination. Most of her teeth had been recently extracted because of pus pockets. The tonsils were embedded and her blood pressure was 160/100. In the middle of the right calf there was a subcutaneous area, firm, non-tender, measuring 1 by 1½ cm., attached to the skin. There were no other masses except those in the breasts but there were scattered macular skin lesions over the lower extremities, not typical of petechiae.

The breasts were large and pendulous. The right breast showed a slight bluish discoloration on 12 o'clock axis 8 cm. from the areolar margin. Underlying this area was a firm mass, 2½ by 3 cm., attached to skin. In the tail of the right breast was a similar mass, 2½ by 2 cm., also with skin attachment. There was a tender, movable node high in the right axilla, 1 cm. in diameter. There were three obvious deforming

lumps of the left breast, located respectively at 11, 12:30, and at 2 o'clock axis. The first of these to appear was firm and discrete; the second and third were cystic in consistency and showed reddening of the overlying skin. There was a soft  $1\frac{1}{2}$  cm. node, freely movable, in the left axilla.

Provisional diagnosis: Multiple cysts, bilateral. The note was made, when this patient was first seen in the clinic, that it was an unusual case and each of the breast masses was to be aspirated to make sure of the contents.

On March 25, 1937, aspiration biopsies were done on five breast masses and on the nodule of the right calf. All these specimens showed thick mucoid material with rare leukocytes. The specimen was negative for acid fast bacilli nor was there any suggestion of tubercle structure. Cultures showed no growth by the fourth day.

On March 29, 1937, a new and similar nodule appeared in the left popliteal space. On April 9, 1937, the patient was admitted for excision of one of the breast nodules and one on the extremities. A local excision of the mass from the upper inner quadrant of the right breast was performed on April 12, 1937.

The specimen consisted of a mass of fatty breast tissue 3 by 2 by  $1\frac{1}{2}$  cm. in size. One portion showed a cystic cavity with yellowish necrotic walls 1 cm. in diameter. Gross diagnosis: Fat necrosis. On section it showed inflammatory fat necrosis.

During the four and one-half years that this patient was followed in the clinic, she developed nodules in the right hip, the right arm, the right groin, the left elbow and in the left axilla. The last nodule was observed in the left breast on January 9, 1941. The patient was seen on two subsequent occasions and no masses were found in either breast. She was last seen on December 8, 1941, and disappeared thereafter.

#### CONCLUSIONS

1. There is no reasonable basis for retaining the qualifying word "traumatic" in the name of the disease which was first described by us as "traumatic fat necrosis of the breast."

2. The best designation for this clinical entity would seem to be the self-explanatory "fat necrosis of the breast," which tells

what it is, where it is, and emphasizes the fact that an identical process is concerned whether it is taking place in mammary fat, in the omentum or in adipose tissue anywhere else in the body.

3. The etiology of fat necrosis of the breast is not known. Trauma, accidental or surgical, is the single most important predisposing factor known at the present time, occurring in nearly 40 per cent of all cases. In our series, a blow on the breast was the apparent predisposing factor twice as often as was the surgical trauma of an operative procedure.

4. The only difference between the forty-one patients who gave a history of trauma compared in a group with the sixty-nine who did not, was the increased incidence of ecchymosis in the traumatic group. All other clinical signs, gross and microscopic pathological findings and subsequent course showed no correlation with positive or negative history of trauma.

5. No correlation has been found between the occurrence of fat necrosis and any constitutional type. Chronic infection as a possible predisposing factor can be ruled out.

6. The importance of obesity, either of the individual or relatively of the breasts themselves, is somewhat less than was previously emphasized although fat necrosis is more apt to occur, with or without preceding trauma, in the overweight group.

7. The lesions of relapsing febrile nodular non-suppurative panniculitis (Weber-Christian disease) as they appear in the breast are indistinguishable from fat necrosis arising in the absence of this syndrome.

8. The clinical signs of fat necrosis of the breast are more variable than has been previously described. The commonest and most confusing sign is attachment to the skin. This is found in about 60 per cent of cases.

9. Approximately 45 per cent of cases of fat necrosis resemble cancer sufficiently closely to make necessary a careful differentiation between the two conditions; in the remaining 55 per cent of cases, widely

differing benign conditions may be simulated. In only 20 per cent of cases was the correct diagnosis suggested by the history or physical signs.

10. Positive diagnosis can be made only by gross and microscopic examination of excised tissue. This is not necessary in all cases, but should be resorted to in the case of any patient in whom there is any doubt whatever that the lesion in question may be a malignant one.

11. Despite the recognition of an increasing number of cases which do not resemble mammary cancer, fat necrosis of the female breast retains its importance to the clinician because of the remarkable similarity it may bear to carcinoma, not only in physical

signs but on gross appearance of cut tissue in the operating room.

12. In closing, let us emphasize once more that no woman should be subjected to the mutilating operation of radical mastectomy unless the presence of a malignant tumor has first been proven.

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MALIGNANT tumors of the breast grow more rapidly and are a greater hazard during pregnancy. In general, the younger the individual, the more rapidly a cancer of the breast will grow. This rapidity of growth makes the prognosis more grave in this group.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).



# EXPERIENCES WITH BONE GRAFTING PROCEDURES FOR THE TREATMENT OF BATTLE CASUALTIES AND WAR INJURIES

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BONE grafting procedures have been performed at the U. S. Army General Hospital, Camp Edwards, Mass. in one hundred instances from May, 1945, to December, 1945, an eight month period. This is by no means an end result study, since patients are relatively soon lost sight of in military installations. The types of patients dealt with in this group were somewhat different than those ordinarily seen and treated in civilian life. As a group these subjects were characterized by severe compound fracture and comminution of bone with an associated bone and soft tissue infection while in many cases there was marked soft tissue loss and fibrosis. Shell fragment wounds which these patients sustained resulted in varying degrees of comminution of bone. Usually there was an associated extensive wound of the soft tissues and the majority of the patients presented post-traumatic osteomyelitis upon their arrival at the hospital.

While overseas these injuries had been treated by débridement, skeletal traction, plaster immobilization and chemotherapy in the form of penicillin and sulfonamides. Open reductions had been performed on some of the fractures and split-thickness or full-thickness skin grafting procedures and secondary closures had been done in many other instances. Of the one hundred patients under consideration, ninety-one (91 per cent) had sustained compound fractures; most of these were comminuted. Nine (9 per cent) had sustained simple fractures while one of these nine had undergone a previous open reduction. Table 1 lists the relative involvement of the various bones and joints involved. The average age

for the group was twenty-six years, the youngest patient being nineteen years of age and the oldest thirty-nine years of age. All the patients were males. Table II lists the various indications for undertaking bone grafting procedures in these patients.

TABLE I  
RELATIVE INVOLVEMENT OF BONES AND JOINTS WHICH  
REQUIRED BONE GRAFTING PROCEDURES

	Per Cent
Femur.....	37
Tibia.....	25
Humerus.....	10
Humerus and shoulder.....	2
Ulna.....	8
Radius.....	7
Radius and ulna.....	2
Clavicle.....	1
Ankle.....	5
Elbow.....	3
	<hr/> 100

Forty-eight hours prior to operation, except in the case of the nine simple fractures, the use of systemic penicillin was instituted. Twenty-five thousand units were given intramuscularly every three hours and this was continued for two weeks following operation. Two teams of operators worked together in most cases. Two operators were engaged in removing a massive tibial graft or an iliac graft, while two other operators exposed the fracture site and prepared the bed for the graft. Intravenous fluids, including 5 per cent glucose in normal saline solution, plasma and whole blood were given routinely during the operative procedure. A fracture table which enabled the application of traction was used to great advantage in grafting the femurs. When tibial bone was utilized as a graft, it was believed that the best type of incision was one which ex-



FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 1. Cpl. C. Compound fracture of mid-shaft of left femur was sustained April 17, 1945, in a plane crash; non-union resulted; preoperative anteroposterior view.

FIG. 3. Cpl. C. Six-screw plate and right iliac bone were applied July 16, 1945; postoperative anteroposterior view.

FIG. 2. Cpl. C., preoperative lateral view.

FIG. 4. Cpl. C., postoperative lateral view.

tended from the region of the tibial tubercle to the lower end of the bone and passed down the lateral border of the crest of the tibia, being so placed that it lay  $\frac{1}{4}$  inch lateral to the tibial crest. The periosteum was then reflected and the full-thickness cortical graft was removed from the anteromedial surface of the tibia with the motor saw. Additional cancellous bone was then removed from the proximal portion of the bone with a curette. The tibial grafts varied in size, some of them measuring up to 9 inches in length. While iliac bone was

used, often the anterior superior spine and both tables of the crest were removed as a single piece 4 or 5 inches in length. The greater portion of the outer table of the ilium was utilized as slabs of bone of varying sizes and additional cancellous bone was obtainable with a curette. The fracture site was exposed through an adequate incision and the scar tissue which had formed between the bone ends and comminuted fragments was excised as completely as possible. The eburnated bone ends were rongeured back to healthy

appearing bleeding bone and the medullary canals were re-established. The bed was then prepared for the graft which was maintained in position with 18-8 SMO stainless steel screws. Additional cancellous bone and bone chips were then

TABLE II  
INDICATIONS FOR BONE GRAFTING PROCEDURES IN THIS  
SERIES OF CASES

	Per Cent
Non-union.....	54
Bone defect.....	16
Frail union with mal-union.....	15
Frail union.....	7
Bone cavity.....	1
Shattered joint.....	7
	<hr/> 100

packed about the fracture site. Following operation the patient was immobilized in a plaster cast or spica except when the femur had been reinforced with a bone graft. In the latter case, a Kirschner wire was passed through the upper end of the tibia at the level of the tuberosity and 15 pounds traction suspension was instituted. Following this quadriceps exercises were begun immediately while knee motion was usually started approximately six weeks following operation. The period of post-operative immobilization averaged twelve weeks for the larger bones and slightly less for the smaller bones. It was considered advisable to use ischial caliper braces for many with grafted femurs when they became ambulatory. It was also found advisable to protect the donor tibia with either a short leg walking cast or a short leg brace after the patient became ambulatory.

Table III lists the various types of bone grafts that were performed in this series. The majority (43 per cent) were tibial onlay grafts. Thirteen per cent dual grafts were accomplished and in 20 per cent stainless steel plates were used in addition to bone. The tibia was utilized as the source of bone in 77 per cent, the ilium in 17 per cent, the tibia plus the ilium in 7 per cent, and the fibula in 1 per cent. One hundred two bones were grafted in the one hundred patients as there were two patients who had both the radius and ulna grafted.

Table IV lists the various complications encountered. Complications of one sort or another were encountered in 40 per cent of the patients. Postoperative recurrence of wound infection occurred in 21 per cent; 6 per cent of these were classified as major

TABLE III  
VARIOUS TYPES OF BONE GRAFTS EMPLOYED

Tibial onlay.....	43
Plate plus iliac bone.....	12
Tibial recess.....	8
Tibial inlay.....	6
Sliding tibial inlay plus plate.....	5
Iliac recess.....	3
Sliding tibial inlay.....	2
Dual, tibial onlay and tibial inlay.....	2
Dual, tibial onlay and sliding tibial inlay.....	2
Dual, tibial onlay.....	2
Dual, tibial onlay and iliac inlay.....	2
Tibial onlay plus iliac bone.....	2
Tibial onlay—intramedullary.....	2
Dual, tibial onlay and tibial recess.....	1
Dual, tibial recess and tibial intramedullary.....	1
Dual, tibial onlay and iliac onlay.....	1
Iliac onlay.....	1
Dual, tibial inlay with plate and tibial onlay.....	1
Dual, tibial intramedullary plus Smith-Petersen nail.....	1
Tibial recess plus iliac bone.....	1
Tibial intramedullary plus iliac bone.....	1
Plate plus tibial bone.....	1
Iliac recess plus plate.....	1
Proximal fibula (for distal ulnar loss).....	1
	<hr/> 102

infections and 15 per cent as minor infections. Ninety-one per cent of the patients had compound fractures to begin with and many were complicated with moderate to

TABLE IV  
VARIOUS COMPLICATIONS ENCOUNTERED

	Per Cent
Recurrences of wound infections following bone grafting.....	21
Major infections.....	6
Minor infections.....	15
Fracture of bone graft.....	8
Refraction of femur.....	1
Fracture of donor tibia.....	5
Following operation.....	3
At operation.....	2
Slipping of bone graft following operation....	3
Temporary tourniquet paralysis.....	2
Total complications.....	<hr/> 40

severe degrees of post-traumatic osteomyelitis which often required one or more sequestrectomies or saucerizations to produce healing of the wounds. Many of the



FIG. 5.

FIG. 5. Cpl. D. Compound comminuted fracture of junction of middle and lower thirds of left radius was incurred April 12, 1945, due to shell fragment wound; preoperative anteroposterior and lateral views.



FIG. 6.

FIG. 6. Cpl. D. Left tibial recessed graft was done on July 23, 1945, because of frail union; postoperative anteroposterior view.



FIG. 7.

FIG. 7. Cpl. D., postoperative lateral view.

patients presented marked soft tissue loss and scarring with resultant circulatory impairment. The problem of how long to wait after the healing of a previously infected wound before bone grafting procedures are performed is a difficult one. The advent of chemotherapy has shortened the time interval but in many instances the previous infection will flare up in spite of its use. No bone grafting procedures were attempted until the soft tissue wounds had remained healed for one and one-half months or longer. It was believed that each patient presented an individual problem. The severity of the preceding infection involving the bone and soft tissues had to be taken into consideration and the condition of the soft tissues overlying the fracture site had to be evaluated. If the previous infection had been severe or if extensive fibrosis and circulatory impairment of the soft tissues had resulted it was believed advisable to wait longer before doing the bone graft. In the case of the

tibia the application of a full-thickness skin graft over the involved bone was found to be imperative.

For the entire series an average of 3.5 months elapsed between the time of the healing of the soft tissue wound and the bone grafting procedure. This interval varied from one and one-half to thirteen months. Of the six patients who develop major infections following operation one subsequently required a below the knee amputation. This patient had presented a massive loss of the distal half of the tibia, and a dual tibial graft was performed. Following the original injury he suffered a rather severe post-traumatic osteomyelitis which had entirely healed four and one-fourth months before the bone graft was performed. Also following the original injury he sustained gangrene of the distal portion of his foot which resulted in the amputation of all his toes. In retrospect, it would have been wiser perhaps to have performed the below the knee amputation



FIG. 8. Sgt. E. Compound comminuted fracture of proximal third of shaft of right femur was sustained January 30, 1945, as a result of rifle fire; non-union resulted; pre-operative anteroposterior view.

FIG. 9. Sgt. E. An eight-inch, left tibial onlay graft was applied August 24, 1945; postoperative anteroposterior view.

in the first place instead of attempting a bone graft. Two patients had bone grafting procedures done to the proximal portions of the tibia. Both of their wounds, which had previously been badly infected, broke down with a resultant partial loss of the bone graft. Of these, one bone graft was performed one and three-fourth months after wound healing had occurred; the other was done four and one-half months after the wound healed. Both patients required further sequestrectomies and application of split-thickness skin grafts. Both wounds healed and will very likely not require further bone grafting. One ununited femoral fracture which had been treated by the application of a massive tibial onlay bone graft developed a profuse postoperative drainage. The wound had healed five and one-fourth months before the bone graft was performed. Several sequestrectomies were necessary and the larger portion of the bone graft was removed eventually as a sequestrum. Another ununited femoral

fracture had presented a purulent discharge for three and one-half months following the original fracture. A massive tibial onlay bone graft was done two and one-fourth months after healing occurred but the original sinus tract reopened following operation and a sequestrectomy without removal of the graft was required. The last major infection was a patient with a large cavity at the proximal end of the tibia. This had previously been treated by several sequestrectomies followed by the application of split-thickness skin grafts. One and three quarter months after the wound was healed, an incision was made laterally through healthy tissue and the periosteum and soft tissues overlying the bone cavity were elevated and the cavity filled with tibial and iliac bone. Following operation this wound broke down with a subsequent loss of the bone grafts and the split-thickness skin graft. After the infection has subsided this patient will require a full-thickness skin graft followed by further bone grafting procedures. Fifteen per cent of the subjects developed minor postoperative wound infections. Nine of these have healed while and one is healing with conservative treatment. Five patients

required the removal of screws and sequestrectomies they are in the process of healing.

Eight per cent of the patients sustained a fracture of the bone graft. All of these were massive tibial onlay grafts; six had been applied to femurs, one to a humerus and one to an ulna. One bone graft fractured four months following operation while the patient was walking without a brace; the second fractured in a similar manner three and one-fourth months following operation; the third became fractured when the patient fell four and one-fourth months following operation; the fourth fractured seven weeks following operation while the patient was still in traction suspension. The graft was fractured when the patient was lifted by the x-ray technician to slip a cassette under the thigh; the fifth sustained a fracture of the graft twelve weeks following operation when the overhead frame fell as he was being removed from traction. In three of these patients loss of position with bowing occurred and an open reduction was performed in each case with the application of a bone plate and iliac bone reinforcement. The fifth patient suffered no loss of position and was returned to traction suspension. In the sixth case a dual tibial onlay graft was applied to the distal end of the femur. At the end of twelve weeks following operation the patient was removed from traction. At that time the roentgenogram revealed fractures of the grafts without loss of position. The seventh case had a massive tibial onlay graft applied to the humerus. The shoulder spica was removed eleven weeks following operation and x-rays at that time revealed a fracture of the graft without displacement and with adequate callus formation. The eighth patient had a dual tibial onlay graft to bridge a defect in the ulna. X-rays taken fourteen weeks after operation revealed a healed fracture of both grafts with solid bony union; this had occurred while the arm was immobilized in a long arm cast. Residual angulation may require an osteotomy for correction.

One patient who had the application of a massive tibial onlay graft to the distal end of the femur had remained in traction suspension for twelve weeks following operation. Two weeks later the physical therapist was attempting to increase motion in the knee and the patient sustained a fracture of the shaft of the femur at its junction with the distal end of the graft. There was no loss of position in this case and further traction suspension was instituted.

Five per cent of the patients sustained a fracture of the donor tibia. Two of these occurred at the time of operation when the graft was removed. There was no displacement and healing occurred uneventfully. Three per cent of the patients sustained donor tibial fractures following operation. All three were unprotected by a brace or cast at the time of the fracture. One fracture occurred four and one-fourth months after operation when the patient slipped and struck his leg against the running board of an automobile, and the second occurred four months after operation when the patient was jumping vigorously during exercises in the reconditioning gymnasium. Both of these patients presented no displacement and were treated by further immobilization. The third patient had a small graft  $2\frac{1}{2}$  inches in length removed from his tibia for the grafting of a non-union of his clavicle. One month following operation he jumped off a step and sustained a compound fracture of the tibia which necessitated an open reduction.

Three per cent of the patients evidenced a slipping of the graft following operation with the resultant loss of position. All three had massive tibial onlay grafts of the femurs and all three were in traction suspension. By altering the traction apparatus, two of the patients were completely realigned while the third was improved sufficiently to insure satisfactory, although not anatomical, alignment.

Two per cent of the patients sustained a temporary tourniquet paralysis of the donor leg. Function returned to normal in both.

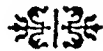
## SUMMARY AND CONCLUSIONS

One hundred bone grafting procedures have been performed during an eight-month period. Ninety-one per cent of these patients presented compound fractures which were extensively comminuted in most instances, and sixteen per cent resulted in a massive loss of a portion of the entire shaft of the bone involved. The wounds were characterized by varying degrees of post-traumatic osteomyelitis and soft tissue loss and fibrosis. Complications were encountered in 40 per cent of the patients. There were 21 per cent recurrences of wound infections following operation. Six per cent were classified as major infections and 15 per cent as minor infections. Eight per cent of the bone grafts became fractured; 3 per cent required surgical correction and 5 per cent required only further immobilization. Three per cent donor tibias were fractured when the patients became ambulatory. Sixty per

cent of the patients have had an uneventful convalescence to date but end result studies are impossible in this series of cases.

The major problem has been that of avoiding a postoperative flare-up of a preceding infection of bone and soft tissues and it is felt that the condition of the overlying soft parts is of the greatest importance. In many cases adequate full-thickness skin grafting of granulating or scarred surfaces as a preliminary step is of major importance in decreasing the incidence of post-operative infections following subsequent bone grafting procedures.

The use of systemic penicillin before and after operation has lessened the time interval between the healing of the original wounds and bone grafting procedures. However, recurrences of infection in bone will occur in spite of its use. The average time interval allowed to elapse between healing of the original wounds and subsequent applications of bone grafts averaged 3.5 months in this series of patients.



# TREATMENT OF LARGE VENTRAL INCISIONAL HERNIA\*

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**V**ENTRAL incisional hernia still poses a major surgical problem. A review of the literature in the last ten years reveals many ingenious methods advocated for hernial repair. Fascia lata as pedicle and free transplant grafts have been used extensively as has preserved beef fascia. The recti muscles have been severed at their pubic insertion, overlapped and sutured to the opposite pubis. Preserved beef fascia has been used over the hernial site being sutured to the fascial edges of the hernia. Extraperitoneal operations have been described with and without excision of the hernial sac, incision into the rectus sheath, folding inward of the rectus fascia and uniting the layers above individually. In the last few years cutis grafts have been utilized for hernial repair.

In 1934, Dr. B. Z. Cashman began utilizing an exceedingly simple extraperitoneal type repair with excellent results. Others in the group have also used this method with similar results. As frequently occurs a careful search of the literature revealed that this technic was not new at all but had been described in great detail by Dr. Irving Haynes of New York in 1913 with a report of seven patients successfully treated. However, no description of this technic nor reference in any detail has been found in the last ten years. Since it has proven of great value in certain large incisional hernias, we believe that this method of repair should again be called to attention as a valuable adjunct in the surgeon's armamentarium. The illustrations in Dr. Haynes' original article are so excellent and clear-cut that it was considered superfluous to make others. The illustrations on technic, therefore, are absolute copies with the original notation from his article.

## TECHNIC

The operative technic is quite simple as evidenced by a careful examination of the illustrations. The old scar is excised and usually the hernial sac is found just beneath the skin. The subcutaneous fat is dissected free from the hernial sac by sharp and blunt dissection being careful not to perforate the peritoneum. As much fat as possible is removed from the sac and the dissection is carried wide in all directions until all the fascial boundaries are identified and exposed for a short distance around the hernial ring. Allis forceps are placed at intervals along the hernial ring edges to identify them easily. If the sac is not to be opened, inversion is begun and the sac is inverted in three to four layers using No. 30 stainless steel wire. The sac may be opened and any intra-abdominal work necessary performed followed by peritoneal closure with catgut and inversion with wire in the usual manner. If the sac is quite large in comparison to the size of the hernial ring, a portion of the sac may be excised before inversion and the peritoneal edges reunited with catgut followed by the inverting sutures of wire as usual. The entire procedure is technically quite simple and the inversion is accomplished with surprisingly little tension. Care is maintained, particularly in inverting the first layer, but there has been no damage to abdominal contents in any of the patients. In some subjects with a marked panniculus lipectomy was done following the hernial repair.

## RESULTS

There were thirty-one patients operated upon at the Elizabeth Steel Magee and St.

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Francis Hospitals since 1934. There have been three other cases not analyzed because they were too recent to include. There were no operative deaths in the series (including the three cases not considered) and only one recurrence, insofar as we have been able to trace the patients. Twenty-five subjects were followed from six months to eight years; the others were not traceable one to four months after operation, hence were not seen again.

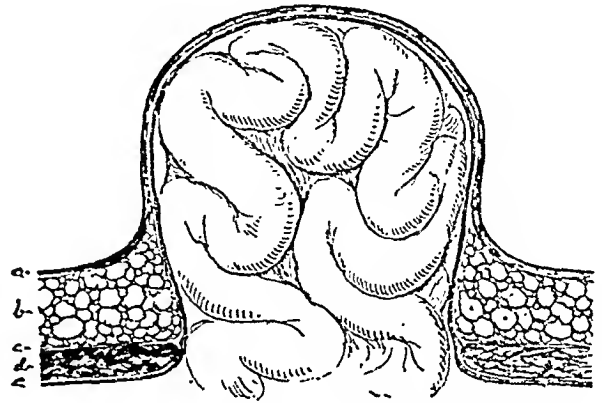
Only the following interesting and illustrative cases will be considered in detail:

#### CASE REPORT

**CASE I.** B. S., a colored female, aged twenty-seven and weighing 206 pounds, was admitted to the Elizabeth Steel Magee Hospital for the first time, August, 1944, with a ventral hernia along the entire length of a suprapubic midline incision. She had had a cesarean section in 1942 after a forty-eight-hour labor. This was followed by an extensive pelvic peritonitis necessitating hospitalization for one hundred days. The hernia occurred soon after discharge and was repaired shortly thereafter, the technic used being unknown. Repair was done again on August 5, 1944, by the inversion technic and the patient had an uneventful postoperative course, being discharged on the thirteenth postoperative day. She was readmitted on the twenty-second postoperative day with a large abdominal wall abscess involving the entire incisional area and necessitating incision and drainage. Despite this massive wound infection there was no recurrence of the hernia.

On November 30, 1946, she was readmitted to the Elizabeth Steel Magee Hospital, eight and one-half months pregnant. A classical cesarean section was done through a right rectus incision made two-thirds above and one-third below the umbilicus to avoid the hernia repair. No difficulty was encountered in performing this cesarean section and no evidence of any recurrence of the hernia could be found. She was discharged well ten days later, although her postoperative course was complicated by an asthmatic bronchitis. In January, 1947, she noted herniation of the recent right rectus cesarean section scar which involved the entire incisional area. She was readmitted to the Magee Hospital in March, 1947, and the new hernia repaired by the inver-

sion technic March 6, 1947. At this time, the repair of the suprapubic hernia was palpated intra-abdominally and was felt as a smooth ridge 1 inch thick and 1 inch wide. This repair at no time showed evidence of weakening. When seen on April 8, 1947, her recent hernial area appeared well healed.



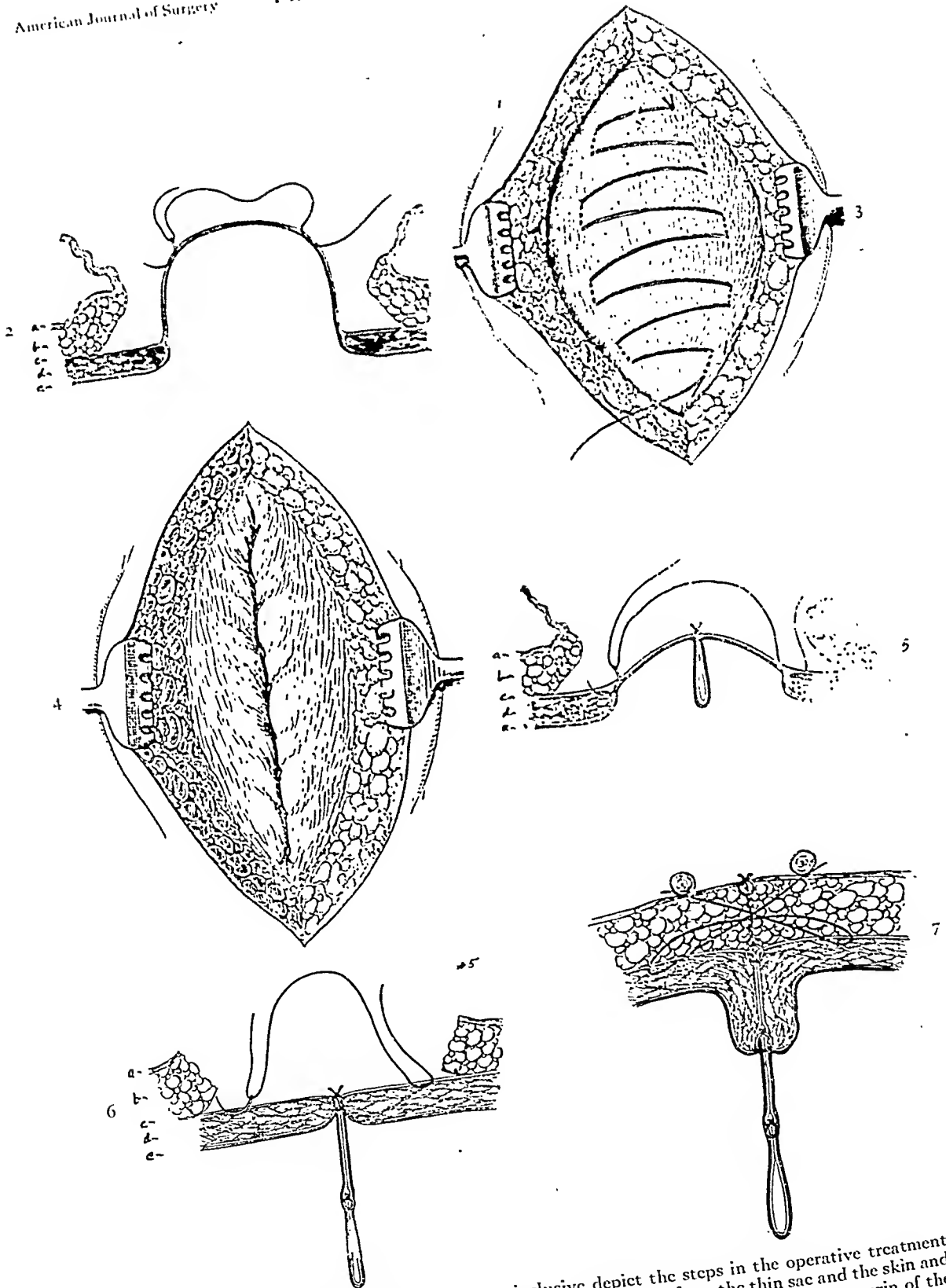
**FIG. 1.** A sectional view of hernia. The contents may be disregarded; the construction of the sac is the important feature. The different structures are lettered the same throughout: *a*, skin; *b*, subcutaneous tissue; *c*, external fascia covering the abdominal muscles; *d*, muscular layer; *e*, internal muscular fascia and peritoneum.

**CASE II.** E. A., a white female, aged twenty-four, weighing 175 pounds, was admitted to the Elizabeth Steel Magee Hospital in May, 1942, with an incisional hernia involving an entire right rectus incision. This occurred after a pelvic laparotomy in 1941. On May 15, 1942, the hernia was repaired by the inversion technic, not knowing that this patient was approximately four months pregnant. This was due to the marked obesity which made pelvic examination difficult, and a history of prolonged periods of amenorrhea in the past without pregnancy. She had an uneventful course and delivered spontaneously on September 22, 1942, at the Magee Hospital.

She was seen again in July, 1945, at which time the hernia repair showed no evidence of weakening, but a small umbilical hernia was noted. This was repaired in August, 1945, using the usual Mayo technic. The upper portion of the old hernia repair was palpated intra-abdominally and the ridge of inverted tissue was easily felt and found to be quite solid. She was again delivered at term on January 29, 1946, by low forceps and on the fifteenth postpartum day there was no evidence of recurrence of either hernia.



## Pink--Repair of Hernia



FIGS. 2 to 7. The illustrations from 2 to 7 inclusive depict the steps in the operative treatment when the sac is not opened. Figure 2 shows the skin dissected from the thin sac and the skin and subcutaneous tissue dissected back from the hernial orifice so as to leave a wide margin of the

CASE III. M. S., a sixty-five year old, white female, weighing 140 pounds was admitted to the St. Francis Hospital in May, 1944, with a ventral hernia involving the entire suprapubic midline scar. This followed a drained pelvic laparotomy in 1926. This patient had had four repairs of this hernia, the last being in 1942. The technic of these repairs was the usual excision of the sac and reapproximation of the abdominal wall in layers. This patient also had partial intestinal obstructive symptoms. On May 2, 1944, the hernia was repaired with the inversion technic. The sac was opened and intestinal adhesions were separated prior to inversion. Follow-up one and one-half years afterward found her with no evidence of recurrence.

CASE IV. C. D., a forty-three year old white female, weighing 285 pounds, was admitted to the Elizabeth Steel Magee Hospital in July, 1942, with a history of ventral incisional hernia repair in 1930. This hernia recurred within a short time after being repaired. On July 29, 1942, this hernia was repaired with the inversion technic and lipectomy performed at the same time. There was no evidence of recurrence three months after operation, but unfortunately, we have not been able to trace this patient further.

CASE V. M. C., a thirty-eight year old colored female, weighing 184 pounds, was admitted to the Elizabeth Steel Magee Hospital in February, 1945, with a ventral incisional hernia 8 inches in diameter above the umbilicus. This followed an exploratory laparotomy through a midline incision above the umbilicus in 1937. On March 1, 1945, the hernia was repaired by the inversion technic. Follow-up since then has revealed no recurrence of the hernia.

Case VI. C. M., a fifty year old, white female, weighing 134 pounds, was admitted to the Elizabeth Steel Magee Hospital in August, 1943. The patient had had a second laparotomy through a suprapubic incision in 1942 which was followed by a hernia in the lower third of the incisional area. This extended for a distance of 4 cm. down over the symphysis pubis. A repair by the inversion technic was performed on August 31, 1943. The patient had an uneventful postoperative course but by January, 1945, the lower portion of the hernia had recurred. This was repaired again on April 27, 1945, by excision of the sac and approximation of the abdominal wall in layers. At the time of operation the upper two-thirds of the hernia repair was found to be quite solid and the recurrence was only in the lower third.

#### COMMENTS

There are interesting data in this series. Sixteen, or one-half of these patients weighed over 180 pounds, one weighing 285 pounds. Three patients were diabetics. Twenty of these subjects were either drained or had a severe postoperative infection preceding the occurrence of the hernia.

In nineteen patients the peritoneal cavity was not opened. In only two patients was it necessary to excise part of the sac. In addition to the hernia repair, one patient had a hysterectomy and in three, lipectomy was done for large abdominal panniculi.

There were fourteen patients in whom the postoperative temperature never rose above 100.4°F. In all patients but two,

adjacent fascia cleanly exposed. The first suture, to take up the slack or fullness in the sac is shown.

FIG. 3. A view of the outside of the hernial sac with the first inverting suture in position.

FIG. 4. To represent the appearance after the first suture has been drawn tight.

FIG. 5. A cross section to show the infolding produced by the first suture and the placement of suture No. 2.

FIG. 6. Suture No. 2 has been tied and the muscle edges brought together. Suture No. 3 is shown in place.

FIG. 7. Suture No. 3 has been tied and the surfaces of the fascia over a wide area have been brought in firm contact. This last suture rolls inward, the edges of the muscles forming the hernial orifice. A figure-of-eight retention suture is shown in position, tied over rolls of gauze, and the skin edges coapted by a last stitch.\*

\* Illustrations from Figures 1 to 7 have been taken from Hayne's article, *New York State J. Med.*, 13: 630-637, 1913.

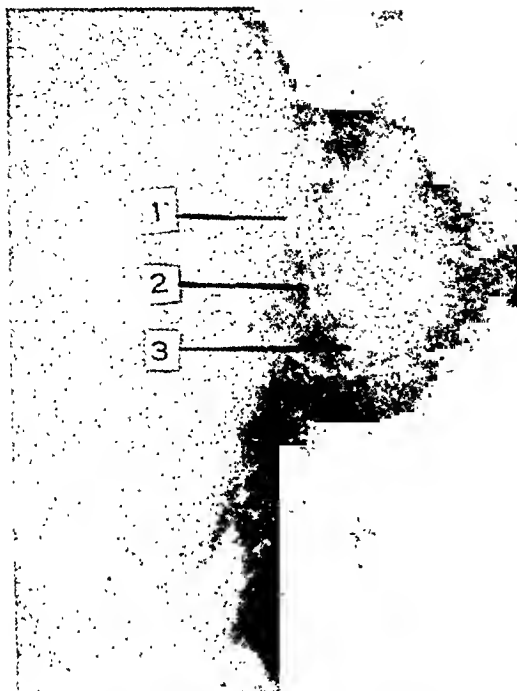


FIG. 8. X-ray taken six months after operation. Note the three layers of steel wire sutures and regularity of fascial edge.

the postoperative temperature was never above 100.4°F. after the third postoperative day. One patient had abdominal distention and a subcutaneous wound infection due to an intestinal injury while separating intraperitoneal adhesions and one patient a mild pulmonary atelectasis. There were two mild wound infections occurring shortly after operation and one large abdominal wall abscess as mentioned in Case 1.

The lack of any severe postoperative complications or marked morbidity has been an outstanding feature in the convalescence of these subjects. That these patients have not been ideal operative risks is indicated by the fact that sixteen of the patients weighed over 180 pounds, three patients being diabetics and five hypertensives.

All of these hernias were fairly large varying from approximately 3 to 10 inches in diameter, the average being between 5 and 7 inches. The youngest patient was eighteen years of age and the oldest sixty-five.

In 1934, catgut and Kangaroo tendon were used as suture material and in 1937

silver wire was utilized. Since that time, stainless steel alloy wire (30 gauge) has been used with the exception of one case. Here the surgeon preferred catgut, having had no experience with wire. We believe that wire has definite advantages since it is non-absorbable and causes minimal tissue reaction.

That this type of repair with wire is of definite value is proven by some of the cases. In Case I the patient developed a massive postoperative wound infection and went to term of pregnancy two years later, without any recurrence of the hernia repair. After her second cesarean section she had a postoperative asthmatic bronchitis which resulted in a hernia through her recent incision but did not disturb the original repair. In Case II, the patient was operated upon not knowing that she was approximately four months pregnant. She went to term and delivered spontaneously four and one-half months after operation. She was again delivered vaginally at term four years later without any evidence of recurrence of the hernia. Case III had four repairs by other technics without wire. Follow-up one and one-half years after repairs with the inversion technic using wire, found her with no recurrence.

The hernia which recurred after utilizing the inversion method was Case VI. The recurrence was in the lower-third of the midline scar while the upper two-thirds remained solid. We believe that this was due to the hernia extending down over the symphysis pubis for a distance of 4 cm.; therefore, it was not suitable for infolding.

The advantage of this method of repair manifests itself in the ease with which the procedure is carried out, the utilization of all the thinned fascia in the sac to build up a stronger wall, the lack of great tension on the suture lines and that should perchance the repair break down there is no disruption of the abdominal wall but merely a recurrence of the hernia. With these large hernias, some with multilocular sacs and with underlying adherent viscera, there is

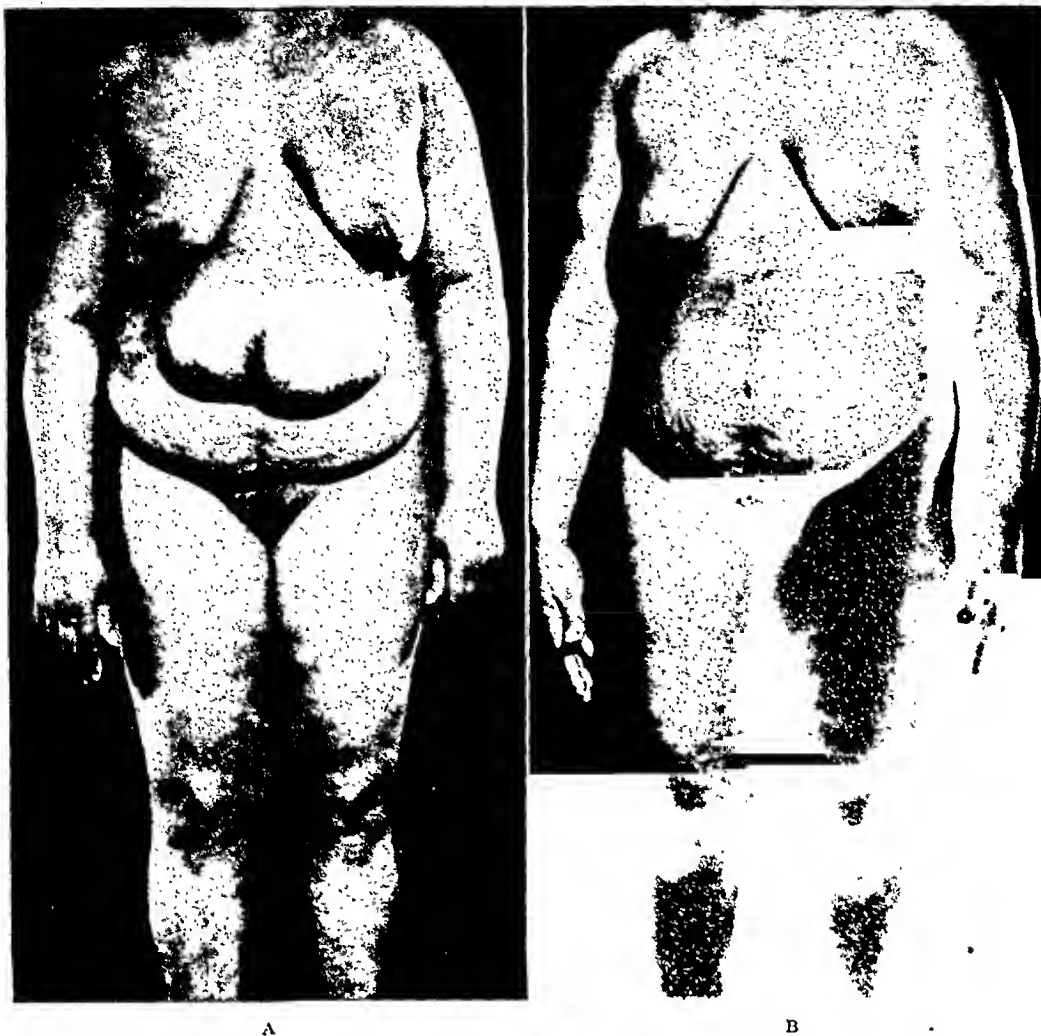


FIG. 9. Case V. A, before operation; B, two months after operation.

considerable saving of time in not having to dissect all the abdominal layers. Also the method of suture is quite simple and time saving. It must be emphasized that the hernia must be reducible and there should be no symptoms of obstruction, partial or complete, if it is to be inverted without opening the sac.

The disadvantage that suggests itself immediately is the danger of perforating the intestine when the sac is not opened and the inverting sutures are introduced. This has not occurred in any of the patients nor in the seven cases reported by Haynes. The only intestinal injury occurred in one case in which the peritoneum was deliberately opened and intestinal adhesions separated. Another theoretical danger to be considered is the increased intra-abdominal pressure created by inverting the large sac and the abdominal walls themselves; however, this

has caused no disturbance at all in any of the patients. Intestinal obstruction and possible strangulation of the intestines could be considered another danger theoretically but practically this has never occurred. It has been axiomatic that where there are any symptoms of partial or periodic partial intestinal obstruction the sac is to be opened and adhesions separated. When there have been no intestinal symptoms the sac has not been opened and none of these patients have developed intestinal obstructive symptoms partial or complete. This repair offers the simplest solution for cases in which the coils of intestine are so firmly adherent that separation would be difficult and in which the adhesions have not produced any tendency towards intestinal obstruction.

Haynes reported on seven patients without recurrence in a period of two years and

advocated this technic for the very large hernias that seem to be almost beyond any of the accepted methods of treatment. We have broadened his concept to include smaller hernias because of the ease of repair as well as excellent results.

#### CONCLUSIONS

1. A simple inversion technic for ventral incisional hernial repair is presented. The technic may be utilized in large and small hernias.

2. Thirty-one cases are presented with one recurrence, no mortality and a very low incidence of morbidity.

3. The recurrence occurred when the hernial sac extended over the symphysis pubis.

4. Stainless steel alloy wire is of value in hernial repair.

I wish to thank Dr. B. Z. Cashman for his help and counsel in the preparation of this material. I also wish to thank the other members of the staff for permission to include their cases in this report.

#### REFERENCE

HAYNES, IRVING S. *New York State J. Med.*, 13: 630-637, 1913.



It should be noted that the so-called umbilical hernia of adult life does not occur through the umbilicus. It is a protrusion through the linea alba just above the umbilicus or, occasionally, just below that structure.

From "A Short Practice of Surgery" by Hamilton Bailey and R. J. McNeill Love (H. K. Lewis & Co., Ltd.)

# PREVENTION OF REPEATED MISCARRIAGE

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THE problem of repeated miscarriage has been troublesome and difficult for the obstetrician. Considerable prominence has been attained in recent literature by new advances in therapy to prevent repeated miscarriages. We wish to go one step further in treatment of this condition.

It is a well known fact that there are a great many miscarriages and we are prone to blame them in many instances on defective fetuses without realizing that there is probably a very good cause for the abnormality in the fetus. We incline to the theory of Mall<sup>1</sup> that many miscarriages are due to faulty implantation and believe that the invasiveness of the trophoblastic layer is dependent upon the amount of stimulation that it receives from the anterior pituitary and the placenta—in other words the depth and strength of attachment of the placenta depends upon the amount of prolan produced, either by the anterior pituitary or by the placenta. Many times we have performed Aschheim-Zondek tests on patients presumably pregnant in whom a vaginal examination failed to establish such a diagnosis. They were approximately six weeks from the last menstrual period and we found only a moderate follicular stimulation or even a negative response, only to find two weeks later on repeating the test a full positive test for pregnancy. This absence of a positive pregnancy test at a time when we normally would expect a full positive response is undoubtedly due to lack of prolan production, and we believe it most likely to occur in those women who have a considerable genital hypoplasia and in whom the uterus barely reaches a normal size at six weeks' gestation. It is not unusual to find in this group of hypoplasias some defect in the production of a good

progestational phase premenstrually, although a poor luteal phase is not ruled out by the absence of genital hypoplasia. It is generally agreed that the production of prolan is highest in the first trimester of pregnancy with a gradual decrease thereafter. There is some evidence to show that the production of estrogen and progesterone lies in the syncytial cells.<sup>2</sup> We also know that a large percentage of miscarriages occur during the so-called "danger period" around three to three and one-half months of pregnancy, at a time when the corpus luteum of pregnancy is degenerating and the placenta takes over its function. It is very reasonable then to believe that insecure implantation of the placenta would result in insufficient production of the hormones necessary to the life of the pregnancy and bleeding at the site of the poorest syncytial penetration, i.e., separation of the placenta. Reduction in corpus luteum excretion and estrogen production frequently precede death of the fetus and miscarriage.<sup>3-6</sup> We are often unable to recover a fetus even though we have had the opportunity to follow the patient from the beginning of bleeding and we believe the same phenomenon takes place as in the rabbit, namely, resorption of the fetus.

It is our belief that Rh incompatibility does not produce miscarriage.

We have not had sufficient experience with vitamin E, except in threatened abortion. In such patients we were unable to obtain a salvage rate of any considerable proportions. In this series of cases no vitamin E was given any patient.

We have on occasion given very large doses of estrogens to patients during early pregnancy. We have in no patient interrupted pregnancy even with doses of 200,000 R.U. of progynon B given in a

period of seven to ten days. We did, however, have one patient who had cramps after the administration of 30,000 R.U., at five months' gestation and therefore discontinued the medication.

Vaux and Rakoff<sup>7</sup> reported good results in treatment of repeated miscarriage with estrogen-progesterone therapy. We also had good results with such treatment for the most part but had a number of failures, including some in patients whom we subsequently have carried through successfully on the medication indicated in this paper. They state that only when death of the fetus has been suspected do the chorionic gonadotropins begin to drop and do so quite precipitously. When the serum gonadotropins fell to 100 M.U. the fetus was usually non-viable. Yet it is difficult to tell whether the death of the fetus definitely preceded the drop in gonadotropins. In addition, no specific mention of frequent repeated readings is made. We also know that in some patients with genital hypoplasia, the estrogen excretion is normal. We had two failures in one patient on estrogen-progesterone therapy when we did not take the general physical make-up of the patient into account: tall woman, heavy bones, masculine pelvis, rather stout, with girdle obesity and other evidences of hypopituitarism.

Rutherford<sup>8</sup> has brought out an excellent point with which we are in complete accord, namely, that a patient who has miscarried is entitled to a thorough work-up to find wherein she fails, wherein her genital system is unable to carry the load of pregnancy, or even function normally during the non-pregnant state. Unfortunately too many good obstetricians and gynecologists do not check their patients carefully after a miscarriage. Every woman who has miscarried twice, or in whom there is evidence of some endocrine disturbance should have the following tests performed at a time when she is not pregnant: (1) Basal metabolic rate, (2) sugar tolerance—three-hour test, (3) endometrial biopsy—premenstrual, (4) examination of hus-

band's semen, and (5) general physical examination and vaginal examination to determine the existence of genital hypoplasia.

Ingram<sup>9</sup> has reported his results with pregnenolone and vitamin E which were favorable in a moderate proportion of cases. Our experience with pregnenolone was less fortunate, as we had a few miscarriages, using doses of 20 to 30 mg. daily. We did not combine the pregnenolone with vitamin E, however. We do not believe that pregnenolone is an actual substitute for corpus luteum hormone in the form of progesterone by injection. Incidentally, we have one patient who has been taking 20 mg. of pregnenolone daily in the second half of the cycle for the past four or five months, who noted increased growth of hair on her arms. This was corroborated; the hair excess is not considerable and is light in color, similar to normal. We have discontinued the medication, temporarily. Has any other such occurrence been noticed? Of course, pregnenolone has possibilities of triple action: estrogenic, corpus luteum and male sex hormone. We do not know which action will result in the body.

Smith, Smith, and Hurwitz<sup>10</sup> have reported increased excretion of pregnanediol in pregnancy from administration of diethylstilbestrol. It is our belief that the natural estrogens act in the same manner. We have used ethinyl estradiol in a few cases, in place of alpha-estradiol, with satisfactory results. The dosage in those cases was 0.05 mg. of ethinyl estradiol three times daily. There were no cases of nausea or other untoward effects.

R. Kurzrok<sup>11</sup> has reported very excellent results in the treatment of repeated miscarriage with estrogen by mouth, and a combination of corpus luteum, prolactin and chorionic gonadotropin by injection. Our results are comparable in percentage of salvage, and we have followed through on similar therapy, with the exception of the prolactin which was not used in our series. Our dosage of corpus luteum was



higher than the average amount he gave, though we are working on a group of cases now, using smaller amounts of corpus luteum hormone, namely, 2 mg. per injection.

We are reporting herein a series of twenty-seven cases of repeated miscarriage treated by the administration of anterior pituitary-like hormone (APL), corpus luteum hormone (CLH) and estrogen. These women had miscarried from one to three times previously.

Treatment in our cases was begun as soon as a diagnosis of pregnancy was established or suspected, and consisted in the following:

Anterior pituitary-like hormone, 1,000 to 2,000 units three times a week until four and half months' gestation, then 1,000 units two times a week till eight months.

Corpus luteum hormone 5 mg. three times a week until four and a half months' gestation, then twice a week until eight months.

Estrogen—alpha-estradiol  $\frac{1}{2}$  to 1 mg. daily, depending upon the extent of uterine and genital hypoplasia present. In a few cases, ethinyl estradiol 0.05 mg. three times a day was given instead of alpha-estradiol with no apparent difference in effect.

**Results.** We were extremely fortunate in our results. There were no interruptions of pregnancy in our twenty-seven cases. Miscarriage did not take place, though there were cases which bled even during treatment. We do not believe the treatment outlined is a panacea for all miscarriages, nor does it preclude further improvements and changes as our conceptions, knowledge and armamentarium improve and grow. The babies delivered were normal, with the exception of one, which was a Mongol; in this case, active movements had been heard at three and a half months, and the fetal heart at four and a half months' gestation. This patient went into labor ten days before term, had a spontaneous easy delivery, the weight of the baby being 5 pounds 10 ounces.

Case histories and pertinent findings follow:

S. M., para two, gravida three, age forty years, had a normal first pregnancy. She had a spontaneous miscarriage at three and a half months with the second pregnancy. She was delivered at term with this pregnancy by low forceps of a 7 pound 3 ounce male infant.

A. R., para two, gravida five, had a normal first pregnancy, followed by three miscarriages at three and three and a half months. Periods occurred every three and a half to five and a half weeks, with a three-day flow. It took several years for the patient to conceive this time. Medical induction was attempted several times up to two weeks past term, and then a cesarean section performed. The baby was a normal 8½ pound boy. The patient looks like a hypothyroid and hypopituitary. The basal metabolism during pregnancy was plus six, plus thirteen. The admitted age was forty-one, but the woman looked much older.

P. S., age twenty-nine, para one, gravida two, had one miscarriage at nine weeks. Her periods occurred every three to six weeks for six days, with occasional flow of four to five days. On first examination at ten weeks' gestation, the uterus was seven to eight weeks in size, with the cervix small and fairly firm. The breasts showed raised areolae, with moderate development of the nipples and a normal amount of gland tissue. The uterus was consistently two weeks behind in size throughout the pregnancy. Delivery was by low forceps as a direct persistent occiput posterior. The baby was a normal female, weight 6 pounds 3 ounces. On examination six weeks postpartum, the uterus was small and normal in size.

A. S., para one, gravida one, had a normal menstrual history. The patient was first seen at six and a half weeks' gestation, at which time the uterus was anterior, two-thirds normal size and firm in consistency; the cervix was infantile and longer than the uterus. There was a soft spot just at the junction of uterus and cervix. The Aseheim-Zondek test was negative but was positive at eight and a half weeks, at which time the uterus was normal in size, with a positive Hegar sign. This patient was treated till eight months' gestation, and was delivered three weeks after cessation of therapy, of a boy weighing 4 pounds 9 ounces, breech presentation. Check-up examination three months after



delivery revealed a uterus about three-fourths normal size. We believe that this type of patient will repeatedly miscarry, and believe that her medication should have been continued till full term.

T. W., age forty, para two, gravida six, had three miscarriages with the first three pregnancies, at two and a half to three months. The fourth pregnancy was carried to term with therapy, and a cesarean section performed because of fetal distress; there was considerable atelactasis at birth, requiring oxygen tent for over a week with complete recovery. The fifth pregnancy ended in miscarriage at three months, but no medication had been given during the gestation. The sixth pregnancy was carried to full term, and a normal child delivered by cesarean section. This baby also suffered from atelectasis, requiring oxygen therapy for a week. Treatment was continuous throughout the entire pregnancy. The patient herself presents outward appearances of a hypopituitary; when hormone therapy was not administered during pregnancy, the patient miscarried each time.

F. W., age thirty-two, para two, gravida three, had originally been seen for sterility. The uterus was small, normal in size, and biopsy showed full secretory phase. Under treatment for a short time, the patient conceived, and was put on pregnenolone 20 mg. daily. She miscarried at about three months, and was seen by one of us at and from the time of rupture of the membranes; no fetus was found. Menstrual periods had begun at eleven years, every thirty days, with a three-day scant flow. This patient has been carried to term twice since, each time on therapy, and delivered by low forceps of living normal children, male and female, weighing between 6 and 7 pounds. The uterus on most recent examination is about three-fourth normal size, the right ovary about twice normal size and believed to be the site of a dermoid.

M. W., age thirty-two, para one, gravida three, had a miscarriage at ten weeks, with the first pregnancy, at which time an intact sac with a five weeks' fetus was obtained. An ovarian cyst 10 by 4 cm. was palpated, and allowed to remain, with gradual recession in size. The second pregnancy terminated in miscarriage at ten weeks, when an intact sac was found with no fetus; the placenta was thin and very poor in appearance. The uterus has

always been about three-fourths normal size during the non-pregnant state. The third pregnancy was carried to term with therapy and a normal female infant weighing 5 pounds 10 ounces delivered by low forceps.

T. L., age twenty-seven, para two, gravida five, began to menstruate at thirteen years of age, irregular periods occurring every three to four months, scant in amount. The uterus was infantile, the size of the terminal phalanx of the index finger. Periods were regulated about once a month with estrogen therapy. There was no difficulty in conception, the first two gestations ending in miscarriages at four months and six weeks, respectively. The third pregnancy was carried to term with treatment during the first seven months. The fourth pregnancy terminated in miscarriage at four months during which time no medication was given. The fifth pregnancy was carried to term without treatment; however, the patient bled and stained almost continuously for the first six months. Deliveries were by low forceps, the babies being girls, weighing 6 pounds 8 ounces and 7 pounds 1 ounce, respectively. We believe this patient was very fortunate to carry through the last pregnancy; certainly she was a threatened abortion throughout the first six months. It is conceivable that had any more placenta separated, she would have been unable to carry through to term.

J. G., age thirty-four, para one, gravida two, was seen for sterility, after the first pregnancy, which ended in miscarriage at two months. She presented no evidences of abnormality and conceived with little difficulty soon after. She was carried to term without difficulty on therapy and delivered by low forceps of a baby weighing 7 pounds, 6 ounces.

H. E., age thirty-eight, para two, gravida five, had a normal first pregnancy with a normal child. The two following pregnancies ended in miscarriage at three months, and a premature birth at seven months which did not survive, respectively. A work-up revealed a uterus slightly smaller than normal; basal metabolism of minus eleven and thirteen, and a good progesterational premenstrual endometrium. With the fifth pregnancy, she was carried on therapy till eight and a half months, and delivered spontaneously almost two weeks before term. The baby weighed 5 pounds 10 ounces, and was a Mongol with thyroglossal and branchial duct remains. Fetal movements

in this case were very definitely audible at three and a half months, and the fetal heart at four and a half months. This is the only abnormal child delivered in our series. The uterus was consistently small throughout pregnancy. The Rh factor was positive in both husband and wife.

F. H., para one, gravida two, age thirty-one, had a miscarriage at two and a half months with the first pregnancy, at which time an intact sac was found but no fetus. The second pregnancy was carried to term. The patient was delivered by low forceps, of a female infant weighing 6 pounds 12 ounces; therapy was given only till the patient was four and a half months' pregnant.

A. L., age twenty-eight, para one, gravida four, had a familial history of diabetes, a brother and two aunts having the disease. However, the patient herself showed no evidence of diabetes. The first three pregnancies terminated in miscarriages at eight to nine weeks. The uterus was a small normal size, and one fibroid the size of a hazelnut was palpable. With the fourth pregnancy, therapy was instituted and the pregnancy carried to term. The patient was delivered by low forceps of a normal male infant weighing 7 pounds 12 ounces. The menstrual history of this woman indicated onset at fourteen years of age, occurrence of periods every five to six weeks, with a three-day light flow.

B. S., age twenty-eight, para one, gravida four, had three miscarriages at two and a half to three and a half months. With the fourth pregnancy, the patient had vaginal bleeding early in gestation, in addition to a complication of phlebitis of both legs with fever. She was carried to term under therapy and a cesarean section performed because of a breech presentation, ruptured membranes and a long slow poor labor. The child was normal.

B. S., age twenty-four, para one, gravida two, had a miscarriage at two months with the first pregnancy. She was placed on therapy during the second gestation, when she began to stain and had a brownish discharge at six weeks. The patient was carried to term and delivered by low forceps of a normal male child weighing 7 pounds 9 ounces.

F. S., age twenty-six, para one, gravida three, had two miscarriages between two and three months. Her general appearance was that of a hypopituitary, heavy bones and a long face.

The third pregnancy was carried to term on therapy and the patient was delivered by low forceps of a normal child.

S. W., age thirty-two, para one, gravida three, had two miscarriages at two and a half to three months. She was treated for irregular periods with APL and estrogens with good results. During her third pregnancy she was started on sheep pituitary but proved allergic to it, and the routine as given in this paper was begun. She was delivered at term of a normal male child weighing 7 pounds 14 ounces. This patient is a typical hypopituitary with heavy android pelvis, moderate obesity, thick bones and a long face. Periods have continued regular since pregnancy, but the uterus is somewhat smaller than normal, especially considering the number of pregnancies.

A. E., para one, gravida two, had irregular periods, usually every eight to ten weeks, and occasionally skipped eight to nine months. The first pregnancy ended in miscarriage at four and a half months. With the second pregnancy the patient was put on therapy and delivered of a normal full term male infant weighing 8 pounds 3 ounces. The uterus on postpartum examination was about three-fourths normal size. The pelvis was android.

E. B., age twenty-two, para one, gravida three, suffered a miscarriage at seven weeks with her first pregnancy. The second pregnancy went two weeks postmature with delivery of an 8 pound 9 ounce baby; therapy had been given. During the third pregnancy she began to bleed early and bled for over a month though therapy had been instituted. She was delivered four weeks postmature of a normal baby weighing over 8 pounds. Therapy had been continued till seven months.

M. A., age twenty-eight, para one, gravida two, had periods every twenty-six days, lasting five to six days. The first pregnancy ended in complete miscarriage at three months. Therapy was not instituted with the second pregnancy until bleeding had already begun and then was continued throughout the pregnancy. Bleeding continued during the first three months. We believe that a larger dosage of APL should have been given, the amount at that time per injection being 500 units. The patient was delivered by low forceps at term of a normal baby boy weighing 9 pounds 1 ounce. Her blood pressure rose to 145/100 during the last month of pregnancy.

F. S., age twenty-two, para one, gravida one, came to us for sterility, and the following results were obtained on series of tests: Basal metabolism minus ten, sugar tolerance 70-86-74-70, on three-hour tests. Her periods began at twelve years of age, every thirty-three days, with a four-day flow. Endometrial biopsy was performed at the time of an expected period and showed an early secretory phase; however, the patient skipped this period, and was proven pregnant two weeks later. The uterus on original examination was about two-thirds normal size and became normal in size at six weeks' gestation. Therapy was continued till eight and a half months. The patient was delivered at term by low forceps of a living normal baby weighing about 6½ pounds.

E. C., age thirty-four, para one, gravida three, had periods every twenty-eight days, lasting five to six days. The patient was treated by us for ovulation bleeding of five years' duration, during which time she bled three weeks out of each cycle. With treatment this condition was corrected. The first pregnancy ended at four months in spontaneous miscarriage with the fetus present. During the next pregnancy the patient was given corpus luteum by injection and estrogen by tablet, and miscarried at three and a half months, the fetus being present on this occasion also. With the third pregnancy, the patient was placed on our present therapy, and despite early bleeding and brownish discharge during the second month lasting about three to four weeks, she was carried to term and delivered of a normal female child weighing 7 pounds 2 ounces. She is again pregnant and is receiving medication, thus far with good results.

E. D., age twenty-seven, para two, gravida two; this patient was treated by us for amenorrhea of two years' duration. Previously her periods occurred about twice a year, and at best the intervals were one to six months apart. With treatment the periods were regulated monthly and the patient became pregnant. Therapy was instituted and the pregnancy carried to term with delivery of a normal child, a girl, weighing 7 pounds 12 ounces. The patient's periods have continued normal since, and a second pregnancy completed to term without therapy, a normal child resulting.

R. F., age twenty-seven, para one, gravida three, had two miscarriages at three and two and a half months with the first two preg-

nancies. The patient has a markedly contracted android pelvis, and the uterus was two-thirds its normal size. Endometrial biopsy revealed a good secretory endometrium, and the basal metabolic rate was normal. The patient became pregnant and was carried to term on routine medication. She was delivered by cesarean section of a normal male infant weighing 6 pounds 5 ounces. The Aschheim test was positive at six weeks' gestation. The patient bled at seven and a half weeks' gestation for almost a week, and the pregnancy rat test was negative at two months. At this time pelvic examination showed the uterus to be soft, about six weeks' gestation in size, and the patient was considered still pregnant. Repetition of the pregnancy test at two and a half months gave a positive response. We believe this patient should have been given much larger doses of APL in the early weeks of pregnancy, as high as 2,000 units, instead of the 1,000 twice a week which had been given prior to the threatened abortion.

R. E., age twenty-seven, para one, gravida five, had three miscarriages at six weeks and one at eleven weeks. The patient suffered with migraine severely. She was carried throughout the fifth pregnancy under therapy and delivered by low forceps of a normal male infant weighing about 7 pounds.

M. C., age twenty-three, para three, gravida three, had a stillbirth at seven months with the first pregnancy. Bleeding had occurred practically throughout the pregnancy. The second pregnancy produced a seven months' live infant weighing 2 pounds 4 ounces which survived. With the third pregnancy the patient was carried to term with therapy till eight and a half months. Delivery was effected of a normal infant weighing 4 pounds 10 ounces.

E. G., age thirty-two, presented a hirsute appearance, with hip obesity and suffered from considerable dysmenorrhea. Her periods began at fourteen years of age, every twenty-eight to thirty-one days, with a three- to four-day flow, scant in amount. The uterus was more or less bicornuate with dimpling at the fundus, one half normal in size with a hypoplastic cervix. On becoming pregnant she was carried to term on therapy and delivered of a normal female infant.

M. L., age twenty-three, para four, gravida five, had normal pregnancies with the first three gestations. Miscarriage with the fourth pregnancy occurred at five months. During the

fifth pregnancy, bleeding occurred throughout the fourth, fifth and sixth months with occasional spotting after the seventh month. Therapy was begun at four months and continued till eight and a half months. The patient was delivered at term, of a normal female infant weighing 5 pounds 8 ounces. We believe it likely that miscarriage would have taken place had therapy not been given, especially in view of the previous difficulty.

#### CONCLUSIONS

1. The treatment and prevention of repeated miscarriage is still in the experimental stage.

2. Any patient who has had two miscarriages, and/or who shows clear evidence of endocrine genital dysfunction or hypoplasia with occurrence of even one miscarriage, should be investigated as to glandular and genital capabilities.

3. Twenty-seven patients who had miscarried from one to three times were treated with combined therapy, consisting of APL, CLH and estrogens. Twenty-seven babies were delivered, all of which were normal, except one, which was a Mongol.

4. There were no postpartum hemorrhages, nor were there any unusual complications during labor or puerperium. Type of delivery was unaffected. Cesarean section was performed in four cases.

5. Labor did not set in earlier than ten days after discontinuance of the injections. In most cases, there was a lapse of approximately three weeks. In several other cases in which CLH had been given without APL, bleeding occurred about three weeks after stopping of the therapy, at four, four and a half, and six months, respectively.

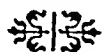
6. We are inclined to give our more recent patients larger doses of APL in the early months, namely 2,000 units three times a week, and trust that this will tend to prevent the bleeding which sometimes occurred in the first trimester.

7. Therapy for repeated miscarriage should be prophylactic. Treatment begun after miscarriage has already threatened is in many instances hopeless, as the fetus is often beyond help or entirely resorbed; however, such treatment should be instituted until a definite diagnosis can be made as some cases will be carried through successfully.

8. Many patients other than those presented in this paper, who presented evidence of endocrine dysfunction, and whom we considered quite likely to miscarry, have been treated by us prophylactically during pregnancy, with excellent results, using the therapy as outlined.

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# ART IN THE NASAL PLASTIC OPERATION

## FROM THE POINT OF VIEW OF THE RHINOLOGIST

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AS the central feature, the nose affects the appearance of all the features of the face. The shape of the nose may correlate the features, producing an harmonious appearance and a pleasing expression, or, on the contrary, it may produce exactly the opposite effect. Indeed, the appearance of each and every feature of the face is influenced by its relation to the size and shape of the nose.

Standard artistic concepts of form, proportion and harmony apply to the effect of the shape and size of the nose on the rest of the features, facial contours and expression. A long face is exaggerated by a long nose; the face appears rounder when the nose is shortened. A moderately protruding chin is accentuated by a long nose, but it becomes inconspicuous and may even be attractive if the nose tilts in the same direction as the chin. A receding chin is accentuated by a retroussé nose. Deep-set eyes look sunken when the bridge of the nose is too high; prominent eyeballs appear to protrude if the bridge of the nose is too low. A high forehead is exaggerated if it is continuous with the nose without a depression below the glabella; whereas a low forehead is less conspicuous if it is continuous with the nose through a high nasal root. A receding forehead is accentuated if the bridge of the nose is high. A high nasal bridge exaggerates broad cheeks; while, on the other hand, it tends to soften the effect of narrow cheeks. A flat or a saddle nose gives a coarse appearance to the face. If the upper lip is too short, proper balance is established by adequate shortening of the nose. By producing harmony of features the objectionable "plastic look" is avoided.

A number of these factors affecting facial harmony and expression are illustrated in the following cases. Practical suggestions in surgical technic are made under each topic.

A long face is exaggerated by a long nose; the face appears rounder when the nose is shortened. (Figs. 1 and 2.)

Shortening of the nose is done on three planes: the midline (septum and columella) and the two alae. The midline should be slightly longer than the lateral planes, or the result will be either a hanging septum or a retracted columella. A hanging septum would require further shortening of the septum, while a retracted columella can be corrected by insertion of a cartilage graft between septum and columella.

In shortening the lateral cartilages, care should be taken that both alae are even, otherwise one nostril will be higher than the other. This result may be avoided by leaving the excess of lateral cartilage until the end of the operation and until the sutures are in place. The excess of upper lateral cartilage will thus be apparent and the exact amount can be removed from each side.

In the operation of Case 1, a partial submucous resection of the nasal septum was performed to correct an existing defect in nasal function. The cartilage removed served as a homogenous cartilage graft for the correction of a saddle nose in another case.

In Case 11, a left inferior turbinotomy was done at the end of the operation to retain proper function. Indeed, some form of intranasal surgical procedure for the maintenance of free passage of air is necessary in over 50 per cent of nasal plastic

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FIG. 1. Case 1. Long nose, short upper lip; A and C, preoperative views; B and D, postoperative illustrations.

operations. The position of the vestibule of the nose is altered when the nose is shortened and adjustment must be made for its new position. A thick or even a slightly deflected septum, a septal spur, a moderately hypertrophied anterior tip of the inferior turbinate will impinge on the vestibule and interfere with the passage of air after the nose is shortened and narrowed. The nasal plastic operation will of itself not correct nasal obstruction; on the contrary, it may produce it. Measures for prevention or correction of nasal obstruction must be planned and carried out in each operation. The form and the function of the nose are anatomically interdependent.

If the upper lip is too short, proper bal-

ance is established by adequate shortening of the nose. (Figs. 3, 4 and 5.)

The effect of a short upper lip is disharmony of features in the lower part of the face. A long septum and nasal spine impinges on the upper lip at the philtrum. The amount of these structures that are removed determines the increase in the size of the upper lip.

Figures 3, 4 and 5 show cases with short upper lips and many other defects. Some of these defects developed as a consequence of fractures which occurred in childhood. The nose is broken more frequently than any other part of the body. Such injuries can very often be traced to early childhood when the child, in first learning to walk, falls frequently. There



FIG. 2. Case 11. Long nose, bulbous tip; A and C, preoperatively; B and D, postoperative y.

may have been what was considered a slight injury with little bleeding, yet a fracture of the nose was overlooked. With growth, deformities develop and the function of the nose is increasingly impaired. Such deformities could be prevented by treating fractures of the nasal bones and septum in the same way as fractures of any other part of the body—by replacement and retention of the broken fragments shortly after the injury and before union takes place. Even a marked displacement of the bone can often be pushed into normal position where it may remain even without splints. But if nothing is done at the time, a complicated operation may later be necessary to achieve the desired result.

In the light of my experience, x-ray is less reliable for the diagnosis of fracture of

the nose than is palpation. In the antero-posterior position, the nasal bones are superimposed on the bones of the skull and face, and many fractures will escape detection in the plate. Careful palpation, however, will readily elicit crepitus and detect displacement. It is safe to assume that whenever the nose has received a severe blow it is a broken nose until proven otherwise.

The variety of malformations that may result or develop from a broken nose is quite considerable. Thus the plastic operation required may be complicated and must be carefully planned. It is usually possible to correct both the inner and outer defects in one operation. The septal cartilage removed can be utilized to correct a saddle deformity which may be present





FIG. 3. Case III. Fracture sustained in childhood; A and C, preoperatively; B and D, postoperatively.

or which may occur in the course of a difficult operation. Occasionally, however, it is necessary to perform two operations: first a nasal plastic, and a subsequent operation on the septum in order to obtain the best results in both form and function of the nose.

A moderately protruding chin is exaggerated by a long nose but becomes unobjectionable, and may even be attractive if the nose is tilted in the same direction. A slightly receding chin is improved when the distance between the chin and the nasal dorsum is reduced by a nasal plastic operation. (Figs. 6 and 7.)

Radical changes of appearance following certain plastic operations, such as may be seen in Figures 6 and 7, produce a psycho-

logical effect on the patient and his family which must be anticipated before the operation. The patient should be an emotionally stable and a psychologically adjustable type who is entirely dissatisfied with the present appearance of his nose. The patient's concept of the existing defects and of the results to be obtained by an operation, should agree with those of the surgeon. If patient and surgeon do not see eye to eye in this matter, the operation should not be undertaken. No matter how esthetically successful the results may be, the operation has failed in its purpose if the patient afterwards continues to complain, "I look so strange; I can't get used to myself." A happier patient is the objective of the operation.



FIG. 4A.



FIG. 4B.



FIG. 5A.



FIG. 5B.



FIG. 4. Case IV. Fracture sustained in childhood; A, preoperative view; B, postoperative view.

FIG. 5. Case V. Curved dorsum, hanging septum; A, preoperatively; B, postoperatively.

A flat or a saddle nose gives a coarse appearance to the face; this is readily corrected by means of cartilage graft. (Fig. 8.)

A nasal plastic operation was performed in Case VIII to narrow the nose, and a submucous resection of the septum was done to correct nasal obstruction. The cartilage removed from the septum was cut into long strips and used for building up the depressed nose. The additional cartilage required had been removed from another case ten days previously. This cartilage was kept on ice in sterile saline solution. The patient was seen two and one-half years after the operation and no evidence of absorption of cartilage was apparent.

Fresh autogenous septal cartilage is undoubtedly the best material for correc-

tion of nasal depressions. Fresh homogeneous septal cartilage is second choice. I have often collected septal cartilage from several cases, kept it in sterile saline solution on ice for two weeks, and then used it for the correction of the saddle nose. Culture of the solution was made before using the cartilage. Fresh rib cartilage taken from the patient adds to the extent of the operation and is not so satisfactory for this purpose as septal cartilage. Rib or septal cartilage preserved in antiseptic solution tends to be absorbed when placed in the dorsum of the nose. This tendency is greatly reduced when the cartilage is used in the amount necessary for building up a chin. Ivory, metals and plastic materials are not absorbed, but they remain

FIG. 6A.



FIG. 6B.



FIG. 7A.



FIG. 7B.



FIG. 6. Case VI. Moderately protruding chin, long nose; A, preoperatively; B, postoperatively.

FIG. 7. Case VII. Moderately receding chin, high nasal profile; A, preoperatively; B, postoperatively.

a foreign body, and there is a tendency for them to be extruded in time. I am now preserving fresh septal cartilage by quick freeze with carbon dioxide snow, keeping it frozen in the ice-chamber of the refrigerator. There is good reason to expect that this will prove a satisfactory solution to the problem of the preservation of fresh cartilage. A report on the results with this cartilage will be made in due time.

Deformities in both nose and chin call for correction of both defects. (Fig. 9.)

A receding chin is usually accompanied by a long nose. A nasal plastic operation does not alone establish harmony of features in these cases. The shortened nose increases the space between the chin and

the tip of the nose, and accentuates the recession of the chin. A combined nasal and chin plastic is required in such cases. The material to be used for building up the chin is similar to that required for building up a saddle nose. The use of fresh septal cartilage is obviously not feasible since the amount required is considerable. The insertion of ivory is the simplest procedure but this remains a foreign body and tends to be extruded in time. Autogenous rib or hip graft is very desirable but it more than triples the extent of the operative procedure. Following the technic of Dr. L. A. Peer, I have used diced septal cartilage preserved in antiseptic solution (metaphen 4 per cent) in several cases. Because of



FIG. 8. Case VIII. Flat, broad nose; A and C, preoperative views; B and D, postoperative views.

the relatively large volume used for building up a chin, the amount of absorption seems to be slight. The procedure with this material is simple and easily carried out. There is reason to believe that the quickly frozen cartilage mentioned in connection with Case VIII will solve the problem of having a supply of fresh cartilage always available.

The nasal tip is the index of a nasal plastic operation. (Figs. 10 to 15.)

Obtaining a well formed tip often calls for the best in skill, judgment and experience on the part of the surgeon. The surgery of the nasal tip is largely the surgery of the two alar cartilages. These cartilages form the major part of the lower end of the nose and determine the shape of the tip and nostrils. Defects of the alar

cartilages are many and varied and they are often a challenge to the ingenuity of the surgeon.

The surgery of the nasal tip is extensive and only a few "don'ts" too often overlooked will be mentioned. The midline incision on the columella for the insertion of cartilage graft in the dorsum of the nose is never necessary and should not be made. All dorsal grafts can be more easily inserted through an intranasal incision and an external scar is thus avoided. In removing a triangular section of alar cartilage for narrowing the nose, care should be taken not to make the nostril too small. Very small and pinched nostrils are unattractive and often ruin nasal function. If the columella is short, it is futile to attempt to hold it up by sutures from the septum pulling the colu-



FIG. 9. Case IX. Receding chin, high nasal profile; A and C, preoperatively; B and D, postoperatively.

mella upward. It may appear satisfactory on the operating table, but in a few weeks the movements of the upper lip in talking and laughing will pull the columella down to its former position. If the tip of the nose must be raised a little, a cartilage graft on the dorsum of the tip will help. In rare and extreme cases the columella must be lengthened by incisions in the upper lip.

Adhesions in the vestibule of the nose resulting from previous operations or trauma produce nasal obstruction and dimpling of the affected alae. Correction by skin grafting is difficult and uncertain. Such adhesions are easily corrected by

incising the scar tissue and suturing a thin strip of rubber between the septum and the lateral wall, leaving the rubber in place for seven to ten days. Uneven alar cartilages are quite common. As a result, the tip of the nose may be longer, broader or higher on one side, and the nostrils uneven. The larger ala should be reduced by excisions to approximately the size of the smaller ala. It is usually difficult in such cases to make the alae and nostrils on both sides precisely alike. It should be emphasized that the slightest loss of tissue at the tip of the nose, especially at the rim of the nostrils, is a serious disfigurement difficult

FIG. 10A.



FIG. 10B.



FIG. 11A.



FIG. 11B.



FIG. 12A.



FIG. 12B.



FIG. 10. Case X. Drooping nasal tip, hanging septum; A, preoperatively; B, postoperatively.

FIG. 11. Case XI. Flat, irregular tip, retracted columella; A, preoperatively; B, postoperatively.

FIG. 12. Case XII. Drooping nasal tip; A, preoperatively; B, postoperatively.

FIG. 13A.



FIG. 13B.



FIG. 14A.



FIG. 14B.



FIG. 15A.



FIG. 15B.



FIG. 13. Case XIII. Bulbous tip; A, preoperatively; B, postoperatively.

FIG. 14. Case XIV. Hanging nasal tip; A, preoperatively; B, postoperatively.

FIG. 15. Case XV. Uneven nasal tip; A, preoperatively; B, postoperatively.



FIG. 16. Case XVI. A and B, identical twins before operation; C, postoperative view of twin in A; D, postoperative view of twin in B.

to repair. This should be borne in mind when carrying out measures of asepsis, making incisions, applying any of the postoperative splints and when making use of compression for narrowing the nose.

In performing nasal plastic operations on identical twins (Fig. 16), care should be taken to maintain the identical appearance. To do this, it is best to perform the operations consecutively, while the memory of the technical details is fresh. In the above cases, one of the twins, B, had had her nose fractured in childhood. Her nose was longer and she had nasal obstruction from a deflected septum, which required a submucous resection. The predominant defect in this pair of twins was the excessive length of the nose.

In shortening a long nose, it is a good precaution to remove only half of the estimated excessive length of the septum first. The rest of the septum requiring removal should be shaved down with a knife gradually, thus guarding against making the nose too short. If the septum and nasal spine impinge on the upper lip, making it too short, they should be removed with biting forceps, using the same precaution of "a little at a time." After the sutures are in place, the length of the nose is carefully inspected. If it is slightly short or slightly long, the required correction should be made at once and thus avoid a subsequent secondary operation. If it is noted that the nose has been made a little too short, it may be immediately lengthened

FIG. 17A.



FIG. 17B.



FIG. 18A.



FIG. 18B.



FIG. 17. Case XVII. Nose overemphasized in photographs; A, preoperatively; B, postoperatively.

FIG. 18. Case XVIII. Nose broken in childhood; A, preoperatively; B, postoperatively.

as follows: The septal mucous membrane is undermined on each side for about three-quarters of an inch and the mucous membrane pulled down to the desired length. The mucous membrane is then sutured to the columella on either side. Perforations between the septum and columella can be avoided by supplementing the through-and-through sutures with sutures of the mucous membrane and columella on each side.

Major effects in harmony of features can often be attained by minor changes in nasal structure. (Figs. 17 to 20.) For professional reasons, the movie actor, photographer's model, television performer, etc., often require an operation which would

otherwise be unnecessary. These cases, especially, require caution and conservatism in obtaining the desired photogenic results with only slight structural changes. The nasal passages should be scrutinized for any obstruction that may interfere with the quality of the voice after operation. The end result should be clearly visualized and the alterations in the structures should be pre-determined to the minutest detail. If a very small bony hump is present, it should be removed with a fine rasp. The saw should not be used for this purpose, as it is likely to remove more than is required, producing the unattractive scooped "plastic-looking" nose. For the same reason, scissors or a Joseph



FIG. 19A.



FIG. 19B.



FIG. 20A.



FIG. 20B.



FIG. 19. Case XIX. Slight imperfections of nose; A, preoperatively; B, postoperatively.

FIG. 20. Case XX. Prominent nose; A, preoperatively; B, postoperatively.

septal punch should not be used for removing a triangular piece of the lower end of the septum in shortening the nose. Too much may be cut away. It is much safer to use a No. 15 Bard-Parker blade to shave away the lower end of the septum cautiously to the desired length. Instruments that have been devised for measuring the nose and features are of little help

in determining the millimeter changes of the soft, flexible tissues of the features which change in form more or less with every slight expression of the face. Calculations based on the use of rigid measuring rods and routine rules can not substitute for the taste, judgment, caution and experience required in a delicate nasal plastic operation.



# CLOSURE OF COLOSTOMIES AND FISTULAS OF THE LARGE BOWEL\*

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**G**UNSHOT wounds of the large bowel have been many and varied in World War II. The management of these cases in the combat areas was superb, as evidenced by the brilliant results in lives saved. The highest praise must be given to those surgeons who, under the most trying circumstances of battle conditions, fatigue, limited personnel and equipment performed so nobly.

The immediate surgical treatment consisted of repair of the damaged colon by suture or by exteriorization of the damaged segment or by an obstructive resection of the traumatized area. Suture was usually reserved for the lowermost portion of the colon where mobilization for exteriorization is impossible. In these cases a proximal colostomy was performed to divert the fecal stream.

In civilian life a colostomy is closed by the surgeon who created it and who therefore knows the true picture of it. In war surgery this opportunity is usually lost. Many of the soldiers with colostomies are returned to the United States for closure. The surgeon in the general hospital in the Zone of Interior is the one confronted with this task. He is aware of the arduous circumstances under which the colostomy was formed. The operative notes may be brief or absent. Therefore, he is presented with a real problem as to the best way in which to complete the surgical care of these soldiers.

Persistently draining fistulas not infrequently complicate these cases. They usually communicate with some portion of the intestinal tract. The purpose of this paper is to present our experiences in dealing with these two problems: (1) closure of colos-

tomies and (2) closure of large bowel fistulas.

## COLOSTOMIES

Thirty-two patients have had their colostomies closed at Newton D. Baker Gen-

TABLE I  
COLOSTOMIES  
Location

Location	No.
Cecum or ascending colon.....	9
Transverse colon (including flexures).....	6
Sigmoid colon.....	17
Total.....	32

eral Hospital. Table I indicates the location of these colostomies. Some of them were of the sigmoid, double-barreled type, usually created for the purpose of diverting the fecal stream from a repaired distal lesion. Some of them had been formed as an exteriorization of an injured portion of the colon. In six patients an obstructive resection of a portion of the colon had been performed. In four of these a double-barreled colostomy was formed. In the remaining two, the two limbs of bowel were brought out at different points on the abdominal wall. (Fig. 1.) The methods of closure used are shown in Table II. During 1944, most of the closures were done extraperitoneally. The intraperitoneal method was used for the most part during 1945.

*Preoperative Care.* It is our belief that the preoperative care of these patients was a most important factor in the ultimate results obtained. The following three points received particular emphasis:

1. *Diet.* In order to get the patient in as good condition as possible for surgery he was put on a high-protein, high-carbohydrate diet. Supplementary vitamins were

\* Read before the Annual Meeting of the Society of the University Surgeons, February 7-9, 1946, New York City.

† Dr. Hertz has resumed his surgical practice in Allentown, Pennsylvania. Dr. Poer has resumed his surgical practice in Atlanta, Georgia.

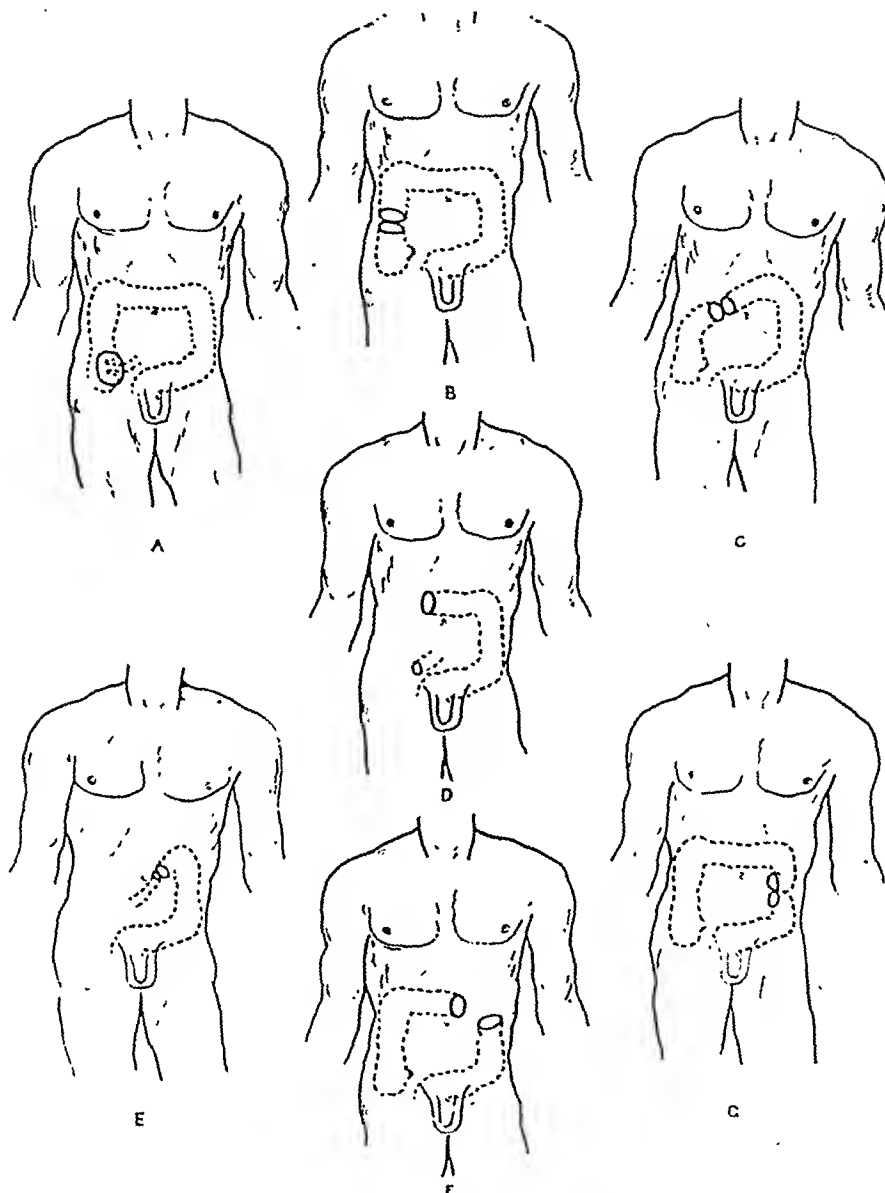


FIG. 1. Colostomy sites: A, exteriorization of wound of cecum with resulting intussusception of ileum into cecum closed by transverse suture extraperitoneally; B, exteriorization of wound of ascending colon; closed extraperitoneally after obliteration of spur; C, obstructive resection of hepatic flexure with creation of double-barreled colostomy; closed intraperitoneally by end-to-end anastomosis; D, resection of right half of colon with ileum and transverse colon brought out through separate incisions; closed intraperitoneally; E, resection of right half of colon with ileum and transverse colon brought out as double-barreled colostomy; closed extraperitoneally; F, resection of splenic flexure of colon with limbs brought out separately; closed intraperitoneally by end-to-end anastomosis; G, double-barreled sigmoid colostomy. This type was closed intraperitoneally by end-to-end anastomosis, or extraperitoneally, after crushing of spur, as indicated in Figures 2 and 3.

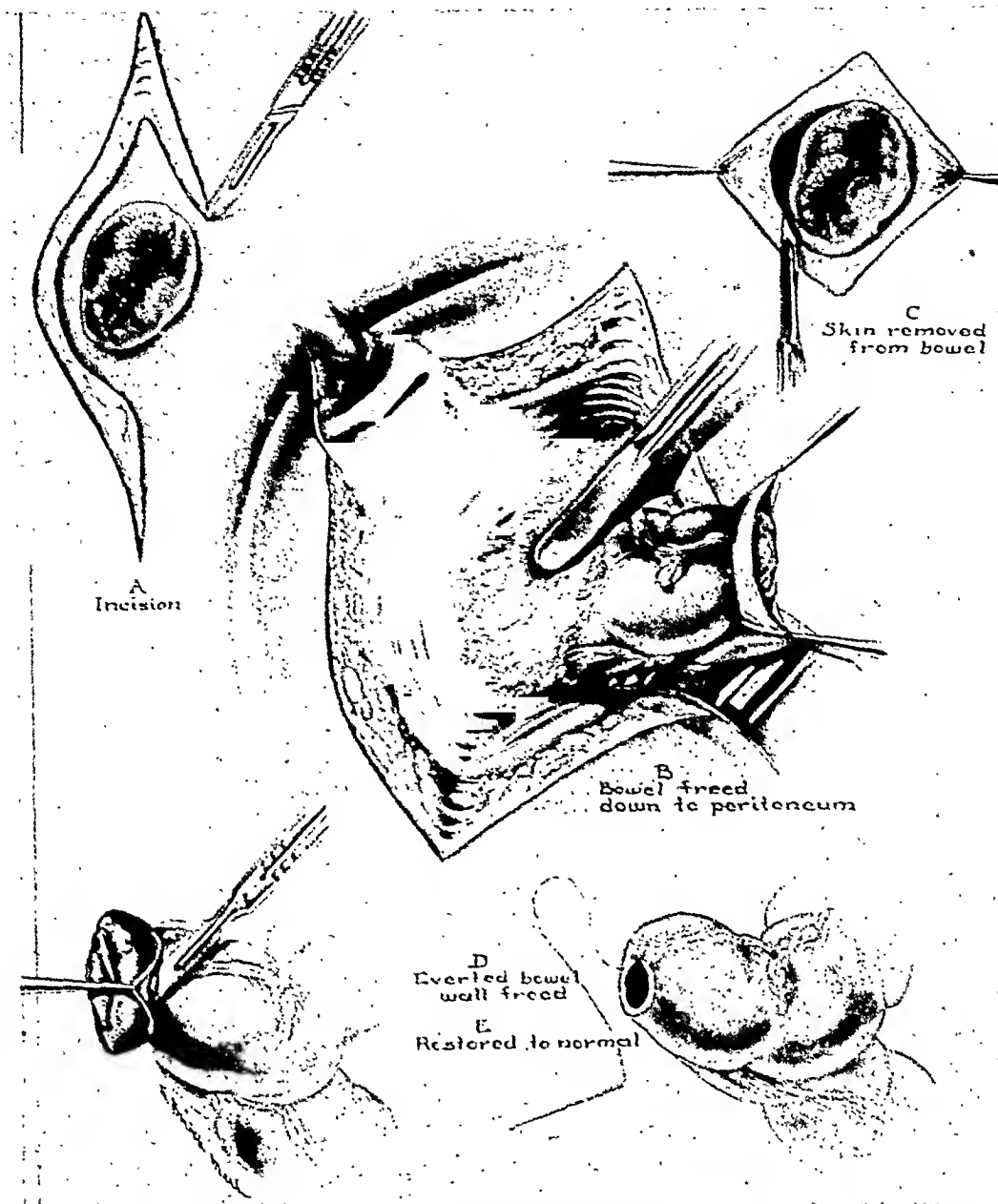


FIG. 2. Operative steps in closure of colostomy after obliteration of spur. A, elliptical incisions around stoma; B, dissection of bowel from fascia and muscle; C, excision of skin from stoma; D, everted bowel wall freed and turned back; E, transverse suture of stoma.

added as indicated. For the three days immediately preceding surgery he was placed on a low residue diet. During the twenty-four hours preceding surgery the patient received only clear liquids.

2. *Mechanical Cleansing of the Bowel.* At the time of arrival at this hospital, following a trip of varying length of time from overseas, many of these patients had a large amount of inspissated material in the distal loop. Accordingly, active measures were taken to clean this out. By using irrigations and enemas of water and oil

this was accomplished. After the distal loop was completely cleaned out, it was irrigated three to five times weekly. In view of the fact that the patient, on arrival at this hospital, had had his colostomy for approximately four months it was usually found that the diameter of the distal loop had decreased moderately. It was believed that these frequent enemas would tend to restore the tone of this distal portion of the bowel and at the same time restore it to a more normal size. On the morning of operation both the proximal and distal loops

of the colostomy were irrigated with sterile saline solution until clear.

3. *Chemotherapy.* Sulfathalidine (phthalylsulfathiazole) was used in fifteen of these cases. It was given for a period of three to five days preoperatively. In view of the reports of Poth it was considered worth while to use this drug. In addition to its effect on the bacterial count, sulfathalidine also reduced the bulk of the feces and rendered them more liquid in consistency.

*Operation.* Elliptical skin incisions were made completely encircling the colostomy. (Fig. 2A.) These incisions were continued downstream toward the peritoneal cavity, separating the fascia and muscle from the bowel wall. The fascia was carefully and thoroughly exposed so that a satisfactory and strong closure could be effected later. (Fig. 2B.) In those cases in which the colostomy spur had been crushed by clamps, the peritoneal cavity was not opened. After separating the attached skin from the colostomy stoma (Fig. 2C) the cuff of everted bowel wall was carefully turned back into its normal position. (Fig. 2D.) Keene has stressed the value of this procedure. This reduced considerably the size of the defect to be closed. It was then possible to close this opening transversely. (Fig. 2E.) The first row was made with a Connell suture or a simple over-and-over suture. A second row of a continuous Cushing suture was used. The suture material used in these cases was No. 00 chromic catgut on an atraumatic needle. The peritoneum was then opened and the closed bowel returned to its normal position within the peritoneal cavity. (Fig. 3F.) It was our belief that this was an important step in the prevention of a post-operative incisional hernia. Dixon and Benson likewise advocated this return of the closed bowel to its normal location within the peritoneum. Pilcher and Nadeau, on the other hand, carefully refrained from entering the peritoneal cavity and instead placed the closed bowel between the peritoneum and the transversalis

fascia. A careful abdominal wall closure was then performed in order to minimize the chances of herniation. (Fig. 3G.) The procedure which has just been described was also found suitable for closing those colostomies in which the colon injury had been exteriorized without the formation of a spur. In these cases, after restoring the everted cuff of mucous membrane to its normal position, a simple transverse closure in two layers was satisfactory.

As pointed out by Keene, there is much danger associated with the application of spur-crushing clamps in these combat injured soldiers. The limbs may have been rotated, the mesenteric border may be in the spur or another loop of bowel may be caught in the colostomy loop. For these and other reasons it was decided in our more recent cases that an intraperitoneal approach with more accurate visualization of the limbs of the colostomy was safer. Accordingly, the colostomy stoma was dissected free from the surrounding tissue as just described and the peritoneum was entered. The bowel was mobilized as well as possible so that its deformity could be studied and the method of closure determined. In those patients in whom a complete transection of the colon had not been done a simple transverse suture sometimes was sufficient to produce an adequate lumen. In the other patients the colostomy limbs were reunited by means of either an end-to-end or a side-to-side anastomosis. In those patients in whom a side-to-side anastomosis was performed the two limbs of bowel were placed in an isoperistaltic position. In the majority of the intraperitoneal closures an end-to-end anastomosis was performed. The open method of anastomosis was used. After resecting a small segment of the ends of the bowel limbs, the anastomosis itself was completed by using two rows of continuous sutures of No. 00 chromic catgut on an atraumatic needle. The repaired colon was then returned to the peritoneal cavity and the abdominal wall closed in layers. In all of

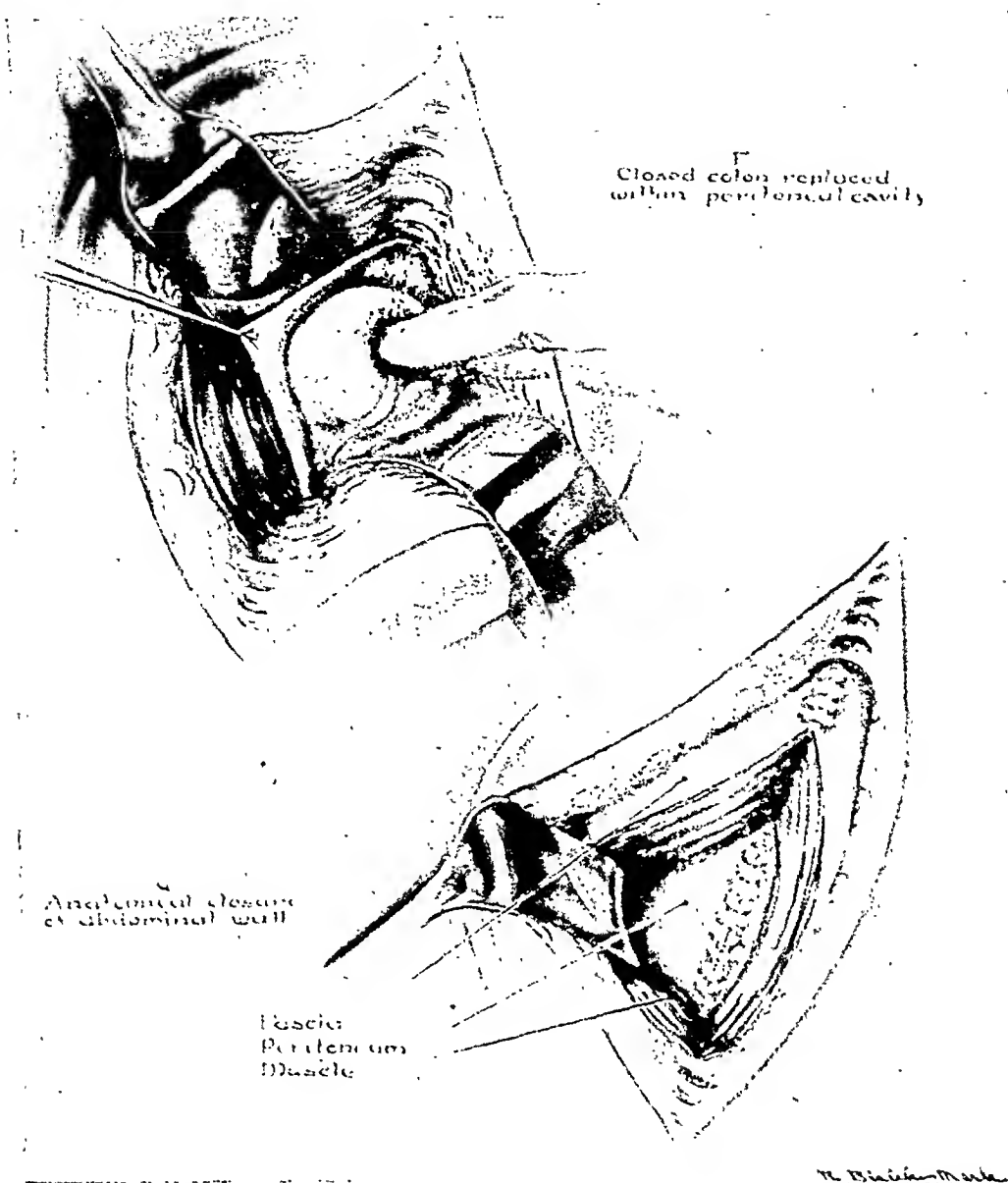


FIG. 3. Operative steps in closure of colostomy (continued). F, closed colon replaced within peritoneal cavity; G, abdominal wound closed in anatomic layers without drainage.

the cases the abdominal wall was closed without drainage.

**Postoperative Care.** This consisted of nothing by mouth for twenty-four to forty-eight hours. Mineral oil, 30 cc. twice daily, was started on the second or third day, and defecation usually occurred on the fourth or fifth day. A low residue diet was begun on the fourth day and a regular diet begun on the seventh to tenth day.

**Complications.** Few complications were encountered in this series of colostomy closures. In two of the patients in whom an end-to-end anastomosis had been performed an intestinal obstruction devel-

oped. In one of these it was only partial and subsided in a relatively short time. In the other case the pain was quite severe and the evidence pointed to a complete obstruction. A cecostomy was performed giving the patient immediate relief. Within twenty-four hours after the cecostomy was performed the patient began to pass gas per rectum. The cecostomy closed spontaneously.

**Results.** In this series thirty-two colostomies were closed, eighteen by an extraperitoneal method and fourteen by an intraperitoneal method. Of the former, twelve were closed as illustrated in Figures

2 and 3 after the spur was crushed. The remaining six had no spur and were closed by a simple transverse suture. Of the fourteen intraperitoneal closures, ten were done by the end-to-end method and four by the side-to-side procedure. (Table II.)

TABLE II  
COLOSTOMY CLOSURES

	No.
Extraperitoneal.....	18
After spur crushed.....	12
Transverse suture—no spur....	6
Intraperitoneal.....	14
End-to-end.....	10
Side-to-side.....	4
Total.....	32

In all patients the abdominal incision was closed primarily without drainage. In none did a wound infection result. This procedure of primary closure is at variance with the delayed closure of incisions as recommended by Pemberton and Black.

The postoperative convalescence was usually very satisfactory. Little cramp-like pain was noted except in the two patients described, with the partial and complete obstruction, respectively. There was no evidence of leakage at any of the anastomoses.

Six to eight weeks after the operation roentgenological studies were made. In some, a minimal amount of narrowing of the lumen was noted; in others there was none. Most of the patients were symptom-free. Four of them complained of occasional mild cramps in the region of the closure.

#### FISTULAS OF THE LARGE BOWEL

In eleven of the patients who arrived at this hospital from combat areas overseas, a fistula of one type or another was present. (Table III.) Some of these were simple, short, straight fistulas running from the buttock directly into the rectum. In others the tract was long, narrow and tortuous passing anterior to the coccyx and sacrum. The external openings of all of these fistulas were located in the skin of the buttocks or gluteal cleft. Ten of these communicated with the rectum and one with the descending colon. All of these cases represented

combat injuries of the involved portion of large bowel. In the primary definitive treatment at the time of injury the soft tissue wounds were débrided and in most cases the wounds of the large bowel were closed. The fecal stream was diverted

TABLE III  
FISTULAS OF LARGE BOWEL

Location	No.
Rectum.....	10
Descending colon.....	1
Total.....	11

from this repaired intestine by means of a proximal colostomy. In three of the cases of rectal fistulas and in the case of the fistula from the descending colon the wound had apparently healed and therefore the colostomy had been closed. Apparently satisfactory healing had not taken place and the fistulas redeveloped subsequent to the closures.

One of the more complicated fistulas consisted of a Y-shaped tract and is illustrated in Figure 4. The tract from the coccygeal area extended upward to a point over the anterior surface of the sacrum where it joined the other tract passing from the surface of the right buttock down through a foramen of the sacrum. This double fistulous tract communicated with the rectum at a point approximately four inches above the anal orifice. Figure 5 illustrates the only fistula which did not communicate with the rectum. This officer sustained a rifle bullet wound which perforated his descending colon and passed out of the body in the left flank through a defect which it created in the posterior crest of the ilium.

Most of these fistulas had been draining for a relatively long period of time. Some of them were treated elsewhere by means of expectant observation. It is our strong conviction that few, if any, will heal spontaneously. It is because of this opinion that we wish to present our management of these cases. Nothing original is claimed for the procedure. It is merely desired to emphasize the fact that surgical treatment is necessary to cure these fistulas.

*Management.* Briefly stated, management of these patients consisted of operation upon the fistulous tract after the patient was in a satisfactory physical condition. The operation itself consisted of unroofing the entire tract and mobilizing the involved rectum or descending colon sufficiently so that the internal opening in the bowel could be closed without tension. The postoperative care consisted of permitting these wounds to heal by secondary intention. In most cases the resultant scar was later revised by excision and primary plastic closure.

In those patients in whom a proximal colostomy was still functioning, the fecal stream was thereby diverted from the freshly sutured bowel wall and normal healing was to be expected. In the four patients in whom the colostomies had already been closed the question was raised as to whether or not a new colostomy should be formed. In all of these cases it was decided to attempt a cure without resorting to this more radical procedure.

*Preoperative Care.* The usual principles of good preoperative care were followed. High-protein, high-carbohydrate diet and supplementary vitamins were prescribed as indicated. The lower bowel was thoroughly cleansed mechanically by means of irrigating solutions of normal saline or potassium permanganate. In those patients in whom the colostomy had been closed earlier the diet was restricted during the last three preoperative days to a non-residue one. In addition, this latter group of patients was given sulfathalidine for three to five days preoperatively.

At times it was very apparent that the fistulous tract communicated with the rectum. At other times demonstration of this fact was not always simple. A satisfactory method of demonstrating the internal opening consisted of the passage of a catheter into the tract as far as it would go. With a proctoscope in place the interior of the rectum was then explored for any evidence of an internal opening. Sometimes this could be picked up readily

by the appearance of a small umbilicated structure or a teat-like deformity in the rectal wall. A water solution of a dye such as methylene blue was then injected through the catheter slowly. The appearance of the colored solution within the rectum demonstrated both the fact that the fistula connected with the rectum and the exact position of the internal opening.

*Surgical Treatment.* The patient was placed on the operating table in the prone position and the buttocks were elevated. The fistulous tract was then uncovered by means of an incision over it. It was frequently necessary to resect the coccyx and sometimes a portion of the sacrum. A sufficient amount of bone was removed so that the internal opening into the rectum could be visualized and sutured. In several cases the fistulous tract extended in a horizontal fashion from the buttock to the rectum. (Fig. 4.) In these cases a portion of the lateral half of the sacrum had to be removed so as to expose the high internal opening. In the case illustrated in Figure 4 a small ureteral catheter was manipulated through the proctoscope and into the internal opening. The catheter was then advanced until it emerged through the external opening on the right buttock. This was of great aid in unroofing this particular portion of the fistula. When the dissection from the external opening had advanced to the sacrum it was found that the tract passed through a small sacral foramen. This portion of the sacrum was resected. After incision of the fascia propria the small internal opening was visualized at the point where the catheter entered the rectal wall. The catheter was removed and the small opening closed by two rows of Lembert sutures.

As a rule it was found desirable to free the rectum from all attachments for a distance of at least 2 or 3 cm. around the internal opening. The opening itself was closed in one of several ways. For the small ones a purse-string suture, reinforced by a second suture, was all that was necessary. In others the opening was closed in a trans-



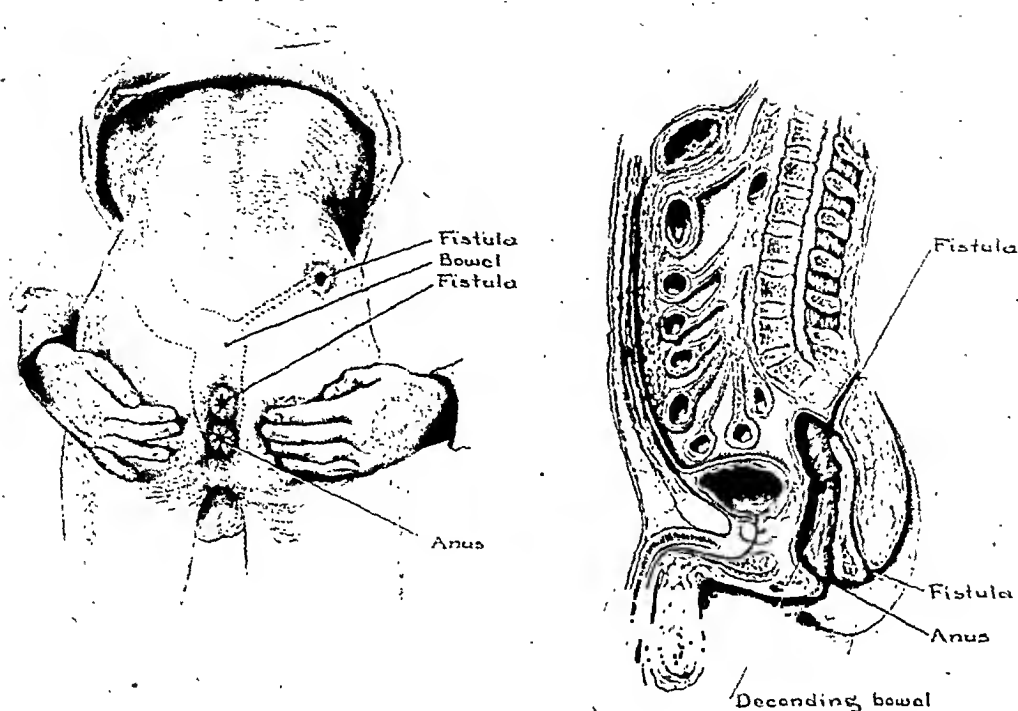


FIG. 4. Rectal fistula with two external openings; one in gluteal cleft posterior to anus, the other in right buttock.

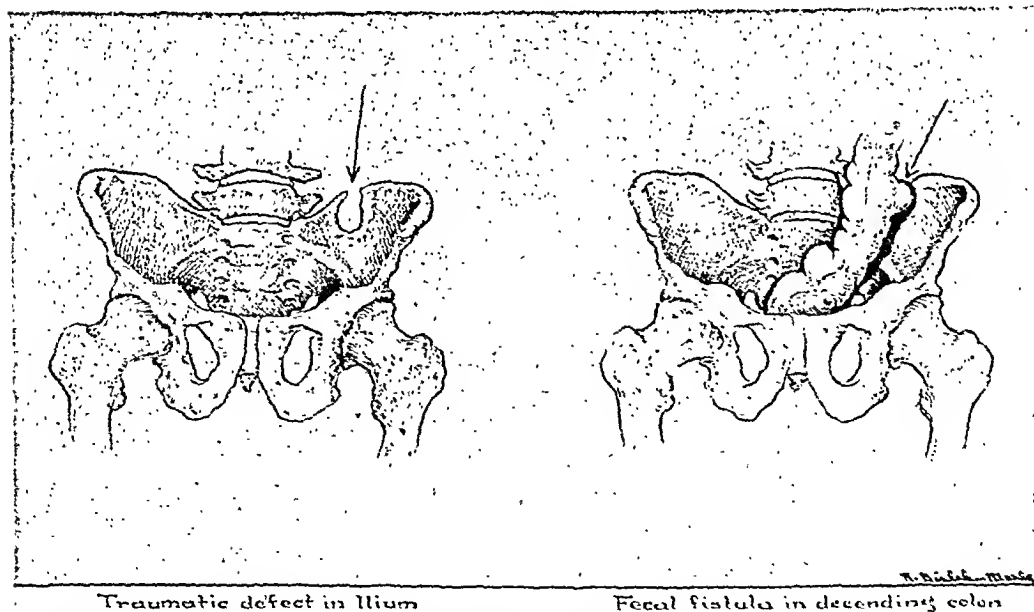


FIG. 5. Fistula, from descending colon to skin of left flank, passing through defect in ilium created by bullet.



FIG. 6. A, demonstration of external opening in right buttock; probe passed directly into rectum; B, exposure of internal opening in rectum; this was sutured transversely; C, complete healing by secondary intention two months postoperatively; D, two weeks after plastic revision of scar.

verse manner using two rows of sutures which inverted the mucous membrane into the lumen. No effort was made to close the wound created by unroofing the fistulous tract. The sides and base of the wound were lined with xeroform gauze and the cavity itself lightly packed with fluffed gauze.

In the four patients in whom the colostomy was no longer present the anal sphincters were carefully stretched while the patient was still on the operating table. It was believed that this maneuver might aid in preventing the development of gaseous pressure within the lumen of the rectum.

One of the fistulous tracts extended from

the left flank through a defect in the ilium into the descending colon. This case is illustrated in Figure 5. The officer's transverse colostomy had previously been closed overseas because the fistulous tract had ceased draining. At the time the patient arrived at this hospital the external opening was very small. Exploration of this tract demonstrated conclusively that it connected with the descending colon. At operation this posterior tract was packed under sterile precautions. Through an oblique incision made just medial to the left anterior superior spine of the ilium, an extraperitoneal exposure of the posterior surface of the descending colon was made. This enabled the internal opening in the

colon to be visualized and closed. The anterior abdominal incision was closed without drainage. The sterile dressing in the posterior wound was then removed and a Penrose drain inserted through this wound to the site of closure of the internal opening. The anterior wound healed without any complications and the posterior wound was completely healed in three weeks. The posterior scar was later revised successfully.

*Postoperative Care.* The patients who had colostomies were allowed to resume a regular diet as soon as they desired it. In the four patients in whom colostomies were no longer present the postoperative diet was one of clear liquids for three days. For the next week a low residue diet was ordered. After this time the patient was allowed to eat what he desired. Rectal tubes were used carefully if there was any suggestion of gas or feces accumulating in the rectum. The wound itself was dressed for the first time on the third or fourth postoperative day. Thereafter dressings were changed every twenty-four to forty-eight hours. The wounds were irrigated and kept clean. In all cases the wounds filled in gradually and without recurrence of a fistula.

These wounds usually healed with an irregular scar, frequently manifested by a valley-like appearance. In most cases this scar was revised by excision and a primary plastic closure. Healing by primary intention resulted with restoration of the normal contour of the skin surface. (Fig. 6.)

*Results and Comments.* This series consists of eleven soldiers who had fistulas of the lower large bowel. All of these fistulas were treated in a similar manner and all went on to a complete cure. The length of time necessary for complete healing of the wound surgically created at the time of the closure of the internal opening varied approximately with the size of the wound itself. The larger defects took three months in which to heal completely. The smaller wounds were healed in a month's time. No

complications were encountered in any of these cases.

It is very interesting that in four of these patients the proximal colostomy had been closed overseas. Despite the fact that the fecal stream was therefore not diverted from the closed internal openings there were no recurrences of the fistulas. The successful cure in these cases probably depended upon a number of factors, of which the following may have been the most important: (1) Careful closure of the bowel opening without tension of any sort; this was made possible by adequate mobilization of the bowel; (2) reduction in the bacterial count of the feces and in the bulk of the feces and the production of a more liquid fecal stream by sulfathalidine and the preoperative dietary regimen; (3) stretching of the anal sphincter at the time of operation and (4) postoperative care with special emphasis on maintaining adequate drainage of the wound and the prevention of the accumulation of gas and feces in the rectum.

#### SUMMARY

1. A presentation has been made of the experience gained at an Army General Hospital in the Zone of Interior in closing thirty-two colostomies and eleven fistulas of the rectum and descending colon.

2. Both intraperitoneal and extraperitoneal methods were used in the colostomy closures. All abdominal incisions were closed without drainage. No deaths or failures occurred. No wound infection developed.

3. The fistulas were successfully cured by operation. This consisted of unroofing the tract, closing the internal opening in the bowel and allowing the soft tissue wound to fill in secondarily. The resulting scar was later revised so as to produce a good cosmetic result.

4. Spontaneous closure of fistulas of the large bowel such as encountered in this series is rare. It is desired to emphasize the necessity of surgical treatment to effect a cure.

5. After an extraperitoneal closure of a colostomy it is suggested that the bowel be replaced within the peritoneal cavity so that an accurate and careful abdominal wall closure can be effected, thereby minimizing the risk of incisional hernia.

6. It is suggested that an intraperitoneal approach to the closure of colostomies is a safe and preferable one in war surgery. This suggestion is made in view of the hazards associated with closing colostomies which were created under battle conditions and whose exact anatomy is unknown to the surgeon confronted with the task of

closing them. A visual approach is better than a blind approach.

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A FISTULOUS communication between the bladder and bowel is uncommon but not rare. The cause is usually trauma, infection, or neoplastic disease. Diverticulitis of the sigmoid, with perforation and abscess formation against the bladder wall, may cause a persistent fistula.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# PRIMARY LYMPHOSARCOMA OF THE STOMACH\*

## STATISTICAL SUMMARY AND CASE REPORT OF A FIVE-YEAR CURE

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IN a review of the literature up to 1937, Taylor<sup>1</sup> collected one hundred forty-seven proven cases of primary lympho-



FIG. 1. Roentgenogram showing large filling defect involving the pars prepylorica and the distal half of the pars media of the stomach.

sarcoma of the stomach. To this group he added five cases from the Presbyterian Hospital of New York making a total of one hundred fifty-two cases. In the interim nine years several series and numerous individual case reports have been added to the growing literature of this subject.

It is our thought that a present day summary of this type of neoplasm may be of interest and would desire to include in this communication the case history of a patient previously reported,<sup>2</sup> who underwent operation for resection of a primary lymphosarcoma of the stomach and is alive and well five and one-half years later.

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### CASE REPORT

A. D., a white male, aged sixty-three, was admitted April 22, 1941 to the Cook County Hospital (surgical service of Dr. J. B. O'Donoghue) with complaints of anorexia and vomiting following the ingestion of food of two months' duration.

Marked generalized weakness of six weeks' duration was present. A weight loss of 50 pounds had occurred during the past year.

The essential physicopathological findings were limited to the abdomen which was scaphoid; tenderness on palpation was present in the epigastrium. No masses were palpable, although the liver edge was just made out below the right costal margin. Examination of the blood and urine were within normal limits. Gastric analysis by the Ewald test meal revealed an absence of free hydrochloric acid; the combined acid, however, was 53 degrees. Blood was absent both grossly and chemically from the stomach contents and also from the stool.

A barium meal was given and a large, rigid superimposable defect involving the entire prepyloric and the distal half of the pars media of the stomach was demonstrated. The opinion was expressed that the lesion was a far advanced carcinoma. Gastrosopic examination confirmed the roentgenological findings. (Fig. 1.)

On May 6, 1941, under cyclopropane anesthesia celiotomy was performed and a large firm mass involving the pyloric and prepyloric portions of the stomach was present. No apparent metastasis to the liver or the periaortic lymph nodes were present, accordingly, a high subtotal gastric resection (Pólya type) was performed.

The resected specimen was submitted to the Department of Surgical Pathology and was described as follows: Grossly: "In the mucosa of the distal end of the stomach is a 5.5 by 6.5 cm. ulcer located on the lesser curvature.

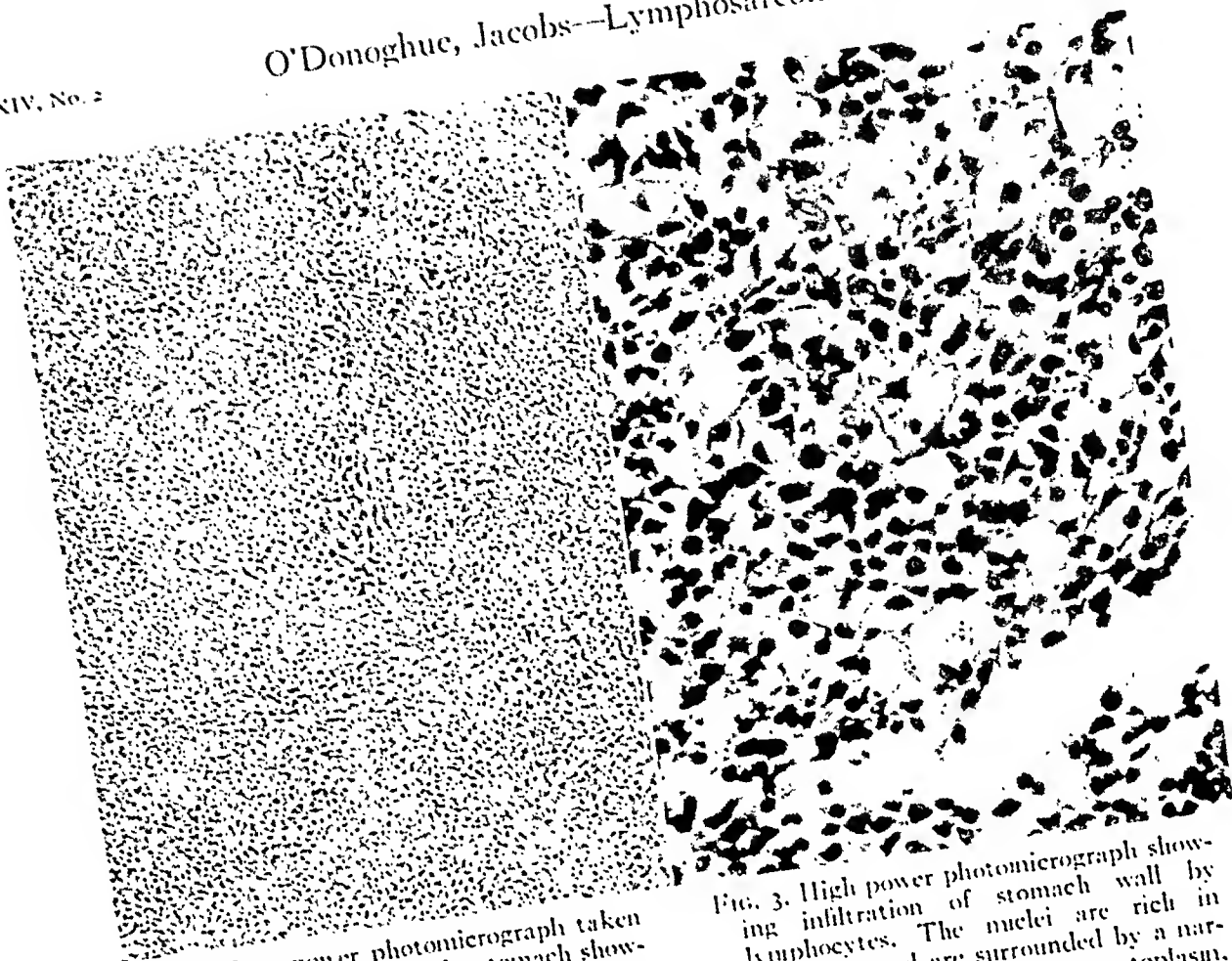


FIG. 2. Low power photomicrograph taken from ulcerated area of the stomach showing diffuse lymphocytic infiltration of the stomach wall (hematoxylin-eosin stain  $\times 90$ ).

FIG. 3. High power photomicrograph showing infiltration of stomach wall by lymphocytes. The nuclei are rich in chromatin and are surrounded by a narrow rim of a pale staining cytoplasm. Variations in size and shape are present (hematoxylin-eosin stain  $\times 600$ ).

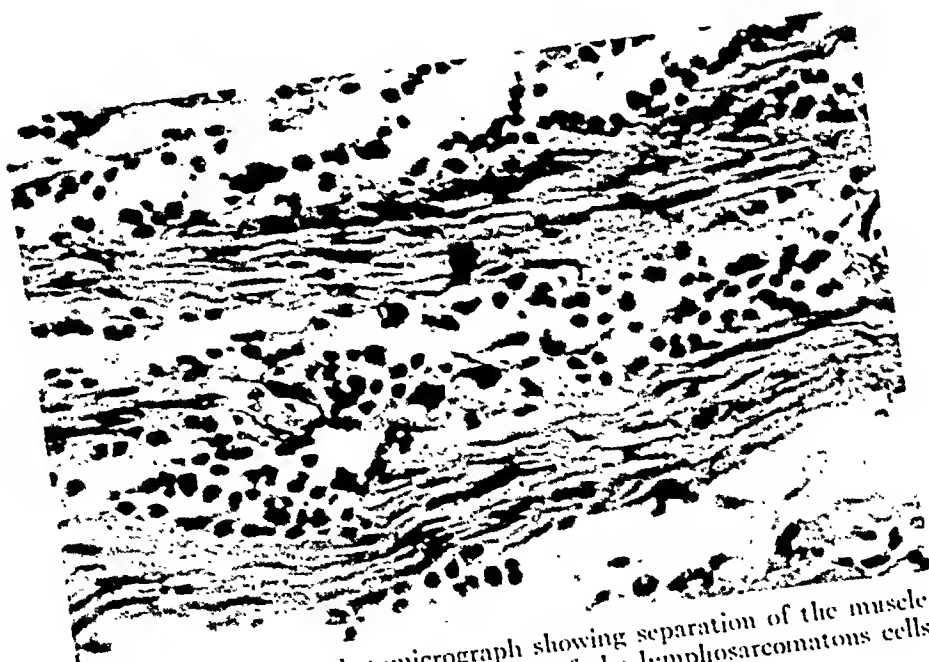


FIG. 4. High power photomicrograph showing separation of the muscle bundles of the stomach by invasion of the lymphosarcomatous cells (hematoxylin-eosin stain  $\times 670$ ).

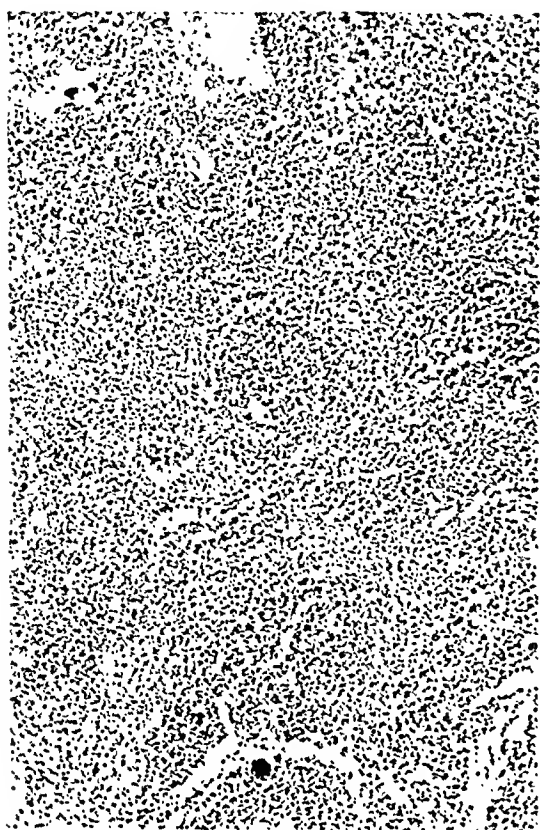


FIG. 5. Low power photomicrograph of a perigastric lymph node. Only one lymph follicle is present. The remainder of the architecture has been replaced by lymphosarcomatous elements (hematoxylin-eosin stain  $\times 99$ ).

The edges of this defect are firm and rolled and the base is clean. Just proximal to the ulcer is a slight narrowing of the lumen and another ulcer measuring 2.5 cm. in diameter is present whose edges are more irregular. Several lymph nodes the largest measuring up to 1.2 cm. in diameter are attached to the pyloric end. Microscopically, sections taken from the ulcerated area reveal a reticulum cell sarcoma of the stomach."

The immediate postoperative course was entirely uneventful and the patient was discharged from the hospital on his fourteenth postoperative day. He was referred for postoperative irradiation and in the ensuing three months received twenty-one treatments, each consisting of 300 r units, the rays being administered over five fields.

Six months after operation the patient had gained 30 pounds in weight, felt stronger and was working. Examination of the stomach by barium meal on December 5, 1941, showed a well functioning stoma and no apparent neo-

plastic involvement of the stomach (Figs. 2 to 6.)

Over five years have elapsed since the patient underwent resection. He has entirely regained his loss of weight, feels stronger and is working at odd tasks. A barium meal given on September 3, 1946, is similar to the examination performed in December 1941. (Fig. 7.)

#### COMMENTS

Gastric sarcoma comprises from 1 to 2 per cent of all gastric neoplasms. The lymphosarcoma type is the most common and comprises from 50 to 60 per cent. Considerable disagreement in the terminology and classification of neoplastic and neoplastic-like lesions of the lymphoid system exists because of the lack of knowledge in regard to the etiology and histogenesis of these lesions.

Ewing<sup>3</sup> classifies sarcoma of the gastrointestinal tract as (1) spindle cell myosarcoma, (2) miscellaneous round cell or mixed cell alveolar sarcoma and (3) lymphosarcoma. Madding and Walters<sup>4</sup> divide the lymphosarcoma type into two forms: (1) reticulum cell sarcoma or (the large round cell lymphosarcoma) and (2) malignant lymphocytoma or (the small round cell lymphosarcoma). This differentiation is emphasized as being of clinical significance inasmuch as the two forms differ in their response to roentgen therapy and the prognosis for survival is different (Table 1.)

From Table 1 it will be seen that a total of one hundred cases of lymphosarcoma of the stomach have been reported by various authors in the period from March, 1937, to January 1, 1946. This reflects the increased incidence of surgical procedures upon the stomach in the past two decades inasmuch as Taylor's series of 152 cases comprises the thirty-three year period from 1893 to 1937. The largest group of patients reported from a single source in our collected series is from the Mayo Clinic where forty-one cases were observed during a period of thirty years.

The prognosis for survival following



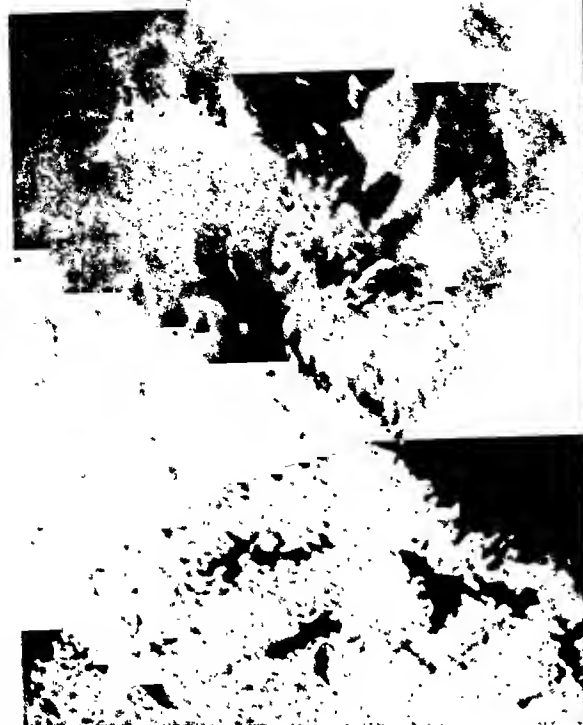


FIG. 6. Roentgenogram taken seven months after operation showing stoma of stomach with no apparent neoplastic involvement.



FIG. 7. Roentgenogram taken five years after operation showing a high subtotal gastric resection with a well functioning stoma and no apparent neoplastic involvement.

removal of a primary lymphosarcomatous lesion of the stomach is better than for carcinoma. The longest span of life recorded to date is in the patient reported by Collins and Carmody<sup>5</sup> who is alive and well twenty-two years after resection. In Taylor's series, thirteen or 11.7 per cent were alive five years following operation. Madding and Walters found that patients with reticulum cell sarcoma treated by surgical procedure had an average life span of 3.58 years, whereas patients with malignant lymphocytoma had an average life span of 5.6 years.

The clinical features of lymphosarcoma of the stomach have previously been reported in publications by Pack and McNeer,<sup>6</sup> Madding and Walters,<sup>4</sup> Yarniss and Colp<sup>26</sup> and others.<sup>2, 27, 29, 30</sup> Inasmuch as there is nothing new to be added at this time the reader is referred to their articles.

With the improvement of radiation therapy in recent years marked regression of far advanced lesions often occurs. Desjardins<sup>7</sup> has stated that "if lymphosarcoma could be diagnosed early, most of

them could be cured by radiation therapy alone." Early diagnosis of tumors of the stomach can only be attained by medical education of the patient to the fact that he should consult his physician for any digestive disturbance early in its course, and secondly the physician through the medium of a detailed history and a complete physical examination followed by radiological and gastroscopic study will usually succeed in arriving at the correct diagnosis and have adequate therapy, namely surgical intervention instituted.

With the advancement of gastroscopic study we believe that one of the greatest aids in making an earlier diagnosis will be available, inasmuch as the involvement of the stomach wall by a lymphosarcoma throws up rugae which are markedly exaggerated and have been described as lobulated without involvement of the mucosa. This finding, together with or without a roentgenological deformity of the stomach in a patient with an organic gastric complaint, justifies a laparotomy since surgical



treatment supplemented by radiation therapy can and does offer these patients a cure.

### SUMMARY

1. One hundred cases of primary lymphosarcoma of the stomach have been col-

TABLE I  
REPORTED CASES OF LYMPHOSARCOMA OF THE STOMACH  
MARCH, 1937 TO JANUARY 1, 1946

Year	Author	No. of Cases
1937	Venable <sup>8</sup>	1
1937	Cabot Case No. 23512 <sup>9</sup>	1
1937	Golob <sup>10</sup>	1
1937	Zaph, Olin and Kirshbaum <sup>11</sup>	1
1938	Howard and Speer <sup>12</sup>	1
1938	Cabot Case No. 24501 <sup>14</sup>	1
1938	Johnson, Lee, Hwong and Case <sup>13</sup>	1
1939	Dumond <sup>15</sup>	1
1939	Archer and Cooper <sup>16</sup>	3
1940	Gabrielli <sup>17</sup>	1
1940	Hochman <sup>18</sup>	2
1940	Ritter <sup>19</sup>	1
1940	Hubeny and Delano <sup>20</sup>	1
1940	Madding and Walters <sup>4</sup>	41
1941	Pund and Stelling <sup>21</sup>	3
1941	Yarnis <sup>22</sup>	1
1941	Koucky, Beck and Atlas <sup>23</sup>	1
1941	Giere <sup>24</sup>	1
1942	O'Donoghue and Jacobs <sup>2</sup>	1
1943	Doran and Doran <sup>25</sup>	1
1943	Yarnis and Colp <sup>26</sup>	8
1943	Schroeder and Schaltenberg <sup>27</sup>	6
1944	Paul and Parkins <sup>28</sup>	1
1944	Marshall and Aronoff <sup>29</sup>	5
1944	Rafsky, Katz and Krieger <sup>30</sup>	11
1944	Porritt <sup>31</sup>	1
1944	Puts <sup>32</sup>	2
1945	Cardon and Greenebaum <sup>33</sup>	1
Total		100

lected from the literature during the period of March, 1937, to January 1, 1946.

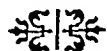
2. A case report is presented of a patient with lymphosarcoma of the stomach who is alive and well five and one-half years following resection.

3. Only through the earlier diagnosis of tumors of the stomach can adequate therapy, namely surgery, be instrumental in the attainment of a cure.

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IN many instances cancer recurs on the site of original operation; this may be several years after the original treatment and is not due to metastasis, but probably is caused by some extensions which were not removed.

From "Metastases Medical and Surgical" by Malford W. Thewlis (Charlotte Medical Press).

# LATE RESULTS IN SURGERY FOR DECUBITUS ULCERS

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THE early results in surgical repair of decubitus ulcers has been excellent. Reports by many observers, Lamon which took place. Figure 6 shows the same ulcer following excision and the use of an advancement flap. Figure 7 shows another

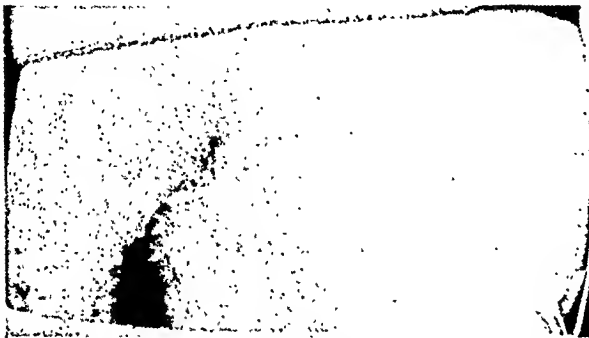


FIG. 1. Ulcer one and one-half years after closure.

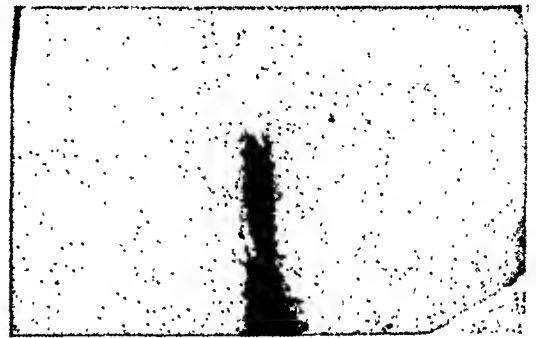


FIG. 2. Another ulcer one and one-half years after closure.

and Alexander,<sup>1</sup> Scoville,<sup>2</sup> White et al.,<sup>3</sup> Barker,<sup>4</sup> Barker, Elkins and Poer<sup>5</sup> show that the decubitus ulcer can be cured in a short time by surgery. However, these reports on the whole deal with the early observations following surgery. Of the eighty patients operated on to date, a series of twenty cases have been observed for a period of one to one and one-half years after surgery. A summary of this group is herewith given.

In the small ulcer, excision and closure has proved a good method in all of the cases employed. In none of the five of these patients has there been a breakdown. Figure 1 shows an ulcer one and one-half years after closure; Figure 2 shows another, one and one-half years after closure.

The late results in grafts to the sacrum have not been as heartening. Of the ten in this series, five have broken down repeatedly in small areas and later required excision and closure. Figure 3 shows a large ulcer preoperatively. Figure 4 shows the same ulcer ten days postoperatively with 100 per cent take. Figure 5 shows the same ulcer one year later with the breakdown

ulcer with the ultimate breakdown one year later. Skin grafting in the ulcer patient should be reserved for those patients with large defects or those in whom a prolonged operation would be contraindicated. In observations of more than 150 patients it is the authors' belief that early skin grafting is beneficial to the patient and also reduces nursing care. Five of these early patients could not have withstood a radical closure at the time the grafting was done. In some places where grafting is not employed the patients are often delayed up to six months for surgery because the clinical condition does not permit surgery. At present we are using huge flaps to fill in the defects in patients that are in good clinical condition; however, observations have not been for a long enough period on these patients to make any definite conclusions.

In treatment of hip ulcers the use of a flap from the surrounding area is the method of choice. Early in the work we tried excision and closure, but due to the suture line lying directly over the trochanter a great many of these broke down immediately after operation. Figure 8

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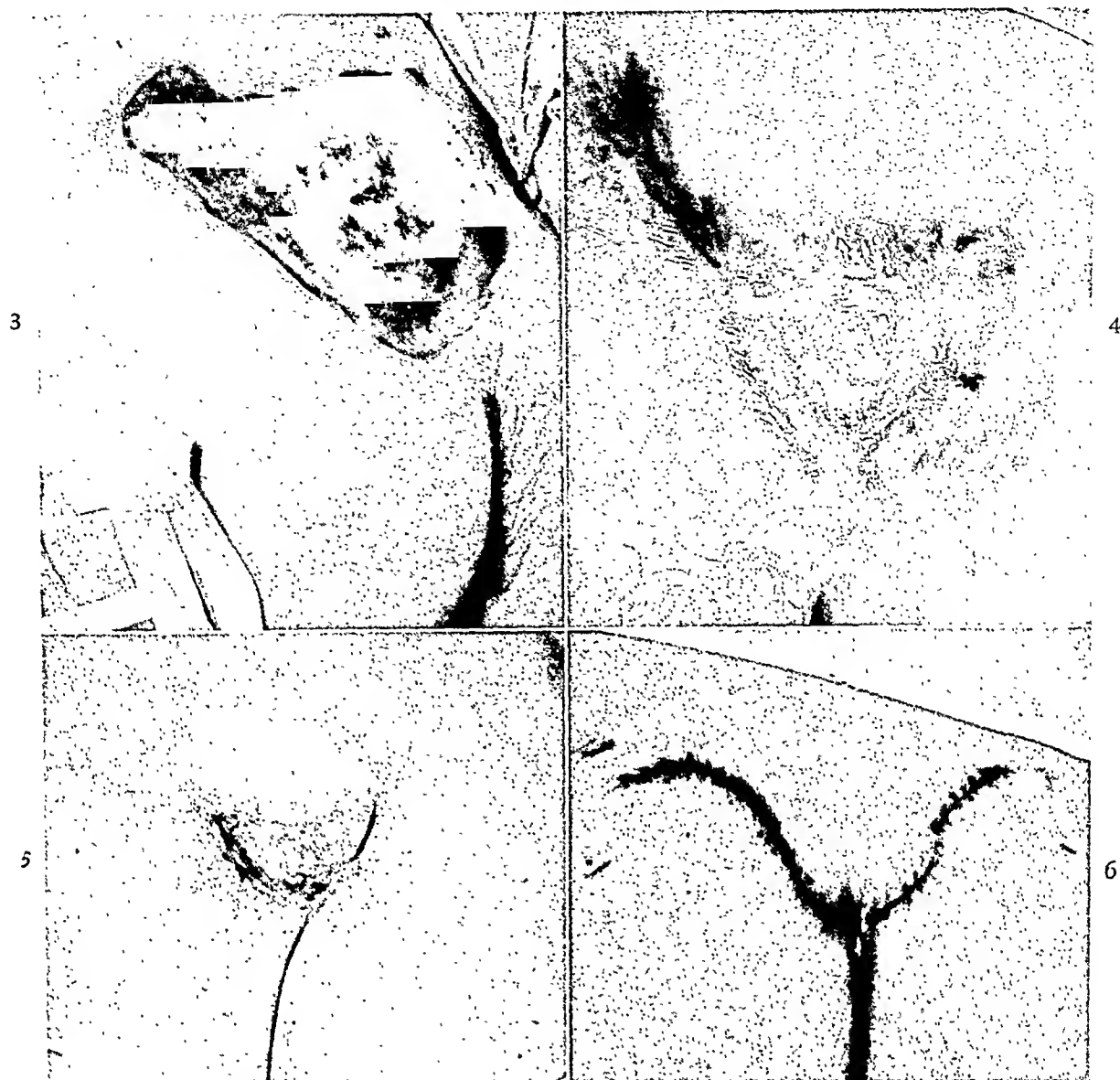


FIG. 3. Ulcer preoperatively.  
FIG. 5. Ulcer one year later.

FIG. 4. Same ulcer ten days postoperatively.  
FIG. 6. Result of excision of graft.

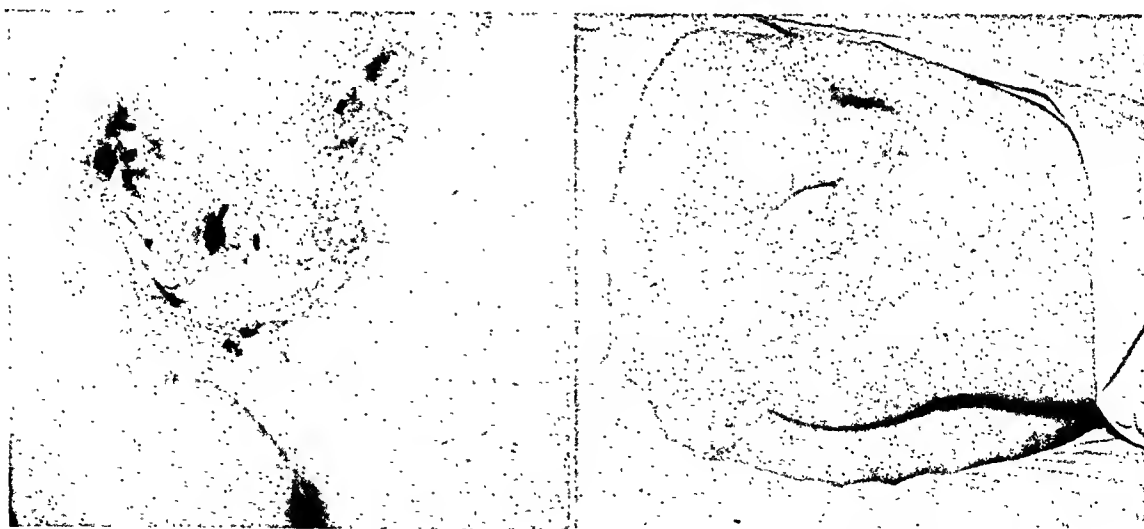


FIG. 7. Breakdown after one year.

FIG. 8. Hip ulcer one year after flap.

shows the results of a flap to the hip and graft of the donor area one year after surgery. In none of the five patients observed for this period has there been any breakdown of the flap.

#### CONCLUSIONS

Of eighty cases, twenty patients with decubitus ulcers have been observed for one to one and one-half years following surgery. On the whole, the results by excision and closure and the use of flaps have been excellent. Grafting, however, should be reserved for patients that are in such poor clinical condition that extensive surgery

and blood loss would be contraindicated. Ulcers which have been grafted will ultimately break down and should be excised and closed when the clinical condition permits.

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THE response to the treatment of varicose ulceration depends on its duration, the extent of the ulceration, and the condition of the surrounding tissues in terms of scarring, phlebitis and lymphatic obstruction.

From "Minor Surgery" edited by Humphry Rolleston and Alan Moncrieff (Philosophical Library).

# A COMBINATION OF SULFANILAMIDE AND 9-AMINOACRIDINE AS A SURGICAL ANTISEPTIC

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ALL wounds are potentially contaminated and may become grossly infected, resulting in great concern to the surgeon and much discomfort to the patient. Wounds seen early should be thoroughly débrided without disturbance of normal tissue and other structures, then treated antiseptically to control possible infections. The surgeon's skill should be supplemented with a reliable and effective antiseptic so that the possibility of wound infection may be reduced to a minimum.

The brilliance of an operation may be impressive but if infection develops and the patient is not cured, the surgeon has failed in his objective. Greater assurance can be given the patient that the results will be favorable provided wound infection can be readily controlled. It cannot be denied that a marvelous technic and the brilliancy of an operation cannot of themselves eliminate the hazard of infections without the aid of an effective antiseptic.

The introduction of sulfonamides seemed to supply an easy and effective method of controlling infection in wounds. Pyogenically infected wounds were first treated by the oral administration of sulfonamides with favorable results in many cases. It was later discovered that topical applications of powdered sulfonamides were more effective. Sulfonamides were accepted with great enthusiasm and their efficacy as therapeutic agents is attested to by the many reports in medical literature.

The topical applications of sulfonamides, powdered or crystals, however, produced several undesirable effects in wounds. The powders in many cases tended to harden in the wounds and produce the effects of a foreign body. The sulfonamides, while effective in controlling infections in a large percentage of cases, apparently delayed

wound healing as evidenced by an anemic, grayish, sluggish appearance of the wound.

Veal and Klepser,<sup>1,2,3</sup> whose observations were later confirmed by a number of other investigators<sup>4-8</sup> found that sulfanilamide 10 per cent with allantoin 2 per cent in a non-greasy, water-miscible base\* was effective in controlling wound infections and stimulating new healthy granulations, thus eliminating the apparent objectionable features of the powdered sulfonamides.

Spotts and Davis<sup>9</sup> observed that allantoin 2 per cent with sulfanilamide 10 per cent in a non-greasy, water-miscible base controlled infections satisfactorily and at the same time increased cellular growth and vascularization of granulation tissue.

The clinical evidence presented in the various reports on allantoin 2 per cent and sulfanilamide 10 per cent in a non-greasy, water-miscible base indicate that this combination has been found to be effective and reliable in controlling wound infections in a large percentage of cases. We, nevertheless, are living in an age of scientific progress in which effective and reliable chemotherapeutic agents are being made more effective and reliable in their assigned rôles.

## ACRIDINES AS ANTISEPTICS

Shortly before and during the first world war, Shiga<sup>10</sup> in Germany, and Browning<sup>11</sup> in England, conducted extensive investigations on the value of the acridines as wound disinfectants.

The most important and better known of the acridine derivatives in the field of chemotherapy are acriflavine and proflavine of the older group and 2-7, diamino-

\* Allantomide Ointment was supplied by The National Drug Company, Philadelphia, Pa.

acridien and 5-aminoacridine of the newer group.

Due to the numbering of the acridine units, much confusion exists in the nomenclature of the acridines, as found in the English and the German system. In the English system the 5-aminoacridine is the equivalent of 9-aminoacridine in the German system.

Rubbo, Albert and Maxwell<sup>12</sup> discovered that the *in vitro* action of 5-aminoacridine is in some respects superior to proflavine and, in addition, found that the substance possesses the desirable feature of being non-staining and non-irritating. They suggested that thorough clinical trials were definitely indicated.

That 5-aminoacridine and its corresponding salts were potential chemotherapeutic agents in wound dressings, was reported by Brownlee and Tonkins.<sup>13</sup>

Perhaps one of the most extensive reports on 5-aminoacridine as a chemotherapeutic drug in anaerobic infection of wounds is that of McIntosh and Selbie.<sup>14</sup> These investigators recommend ointments and mixtures of sulfathiazole and acridine antiseptic. They found 100 parts of the sulfa drug to one part of the acridine antiseptic was most effective.

Editorially, in the British Medical Journal,<sup>15</sup> it is stated that the reason for past failures with the flavines was due to "wrong choice of compounds and misapplications. It (proflavine) should certainly be given further trial in combination with other agents for the prevention and treatment of wound infections." Shortly following this suggestion, the J. A. M. A.<sup>16</sup> commented editorially that "it is desirable to investigate further the possibility of the acridine compounds and particularly proflavine."

The colorless flavine, 5-aminoacridine, when used in a 1 per cent solution, in equal parts of spirits and water, as a skin sterilizing agent approximately six hours preoperatively, according to Bonney and Allen,<sup>17</sup> gave very effective results. Their final conclusion is that the solution they describe, "if used in the manner set forth,

efficiently and inoffensively sterilizes the skin."

Poete<sup>18</sup> treated 120 patients prophylactically and curatively with 5-aminoacridine hydrochloride. His results were very good; immediate sepsis control was secured in all but five cases which cleared within a short period. He noted a particularly active effect of the antiseptic against hemolytic staphylococci. In a series of fractures he observed that "it appears to favor bone repair."

It was reported by Goetchius and Lawrence<sup>19</sup> that 9-aminoacridine derivatives exhibit bactericidal effects in high dilutions, particularly against anaerobic organisms.

#### ALLANTOIN SULFANILAMIDE 9-AMINOACRIDINE OINTMENT

With an apparent synergistic action existing between sulfonamides and 9-aminoacridine, it was decided to incorporate the latter chemotherapeutic agent in the allantoin 2 per cent sulfanilamide 10 per cent combination in a non-greasy, water-miscible ointment to the extent of 1 part in 500, and compare this clinically with the allantoin 2 per cent sulfanilamide 10 per cent in the same type ointment base.

*Method of Treatment.* One hundred fifty patients were treated with the allantoin 2 per cent, sulfanilamide 10 per cent, 9-aminoacridine 1:500 in a non-greasy, water-miscible ointment base.

The conditions requiring surgical treatment in these patients represented traumatic wounds, postoperative wounds, chronic leg ulcers, decubitus ulcers, second and third degree burns, frostbite and amputation stumps. Practically all such lesions are potentially contaminated or grossly infected. The primary consideration should be for control of the infection and the promotion of the natural process of healing.

Proper preparation of the wound by making its entire surface accessible to the application of the allantoin, sulfanilamide, 9-aminoacridine ointment is the first measure taken in the treatment. It should be

stressed that all necrotic tissue must be removed and all pus pockets and undermined areas drained in order that the ointment may come in contact with all the affected areas of the wound. In the more extensive wound a suitable anesthetic should be used to control pain during the wound preparation.

After the wound has been properly prepared the allantoin, sulfanilamide, 9-aminoacridine ointment is applied in a liberal amount, covered with vaseline gauze over which is placed a dry dressing followed by a light pressure bandage. In a majority of cases dressings were changed at three-day intervals than at five-day intervals until healing was complete. Prior to each new application of the ointment, the wound was cleansed with hydrogen peroxide and sponged dry being careful not to disturb any new granulations.

*Record of Observations.* The incorporation of the chemotherapeutic agent, 9-aminoacridine, into the allantoin 2 per cent, sulfanilamide 10 per cent ointment apparently enhanced the effectiveness of the latter combination. In many instances, wounds which showed the presence of streptococci and staphylococci were made bacteriologically negative more rapidly with the 9-aminoacridine containing ointments. The time was reduced approximately 30 per cent. In the case of *Bacillus coli* infections the allantoin, sulfanilamide, 9-aminoacridine was considerably more effective than the allantoin, sulfanilamide ointment.

Used prophylactically the allantoin, sulfanilamide, 9-aminoacridine ointment was effective in all but two patients, both abdominal surgery cases. These developed *Bacillus coli* infections in the operative wound but were successfully controlled with wet dressings of 9-aminoacridine (1:1000) solution. As soon as the infections were under apparent control, approximately thirty-six hours, the ointment was reapplied and the wound went on to heal successfully.

The infections in the wounds being con-

trolled, vascularization in the granulation tissues and marginal epithelization progressed rapidly. Compared to various other methods of therapy, such as wet dressings, powdered sulfonamides, and several other ointment preparations, healing progressed on an average of 30 per cent more rapidly. The allantoin, sulfanilamide, 9-aminoacridine ointment proved more effective in the presence of blood and exudates than did the ointment without the 9-aminoacridine. At no time during the course of this therapy were systemic reactions, referable to the application of the ointment, observed in these patients. Local reaction was observed in only one patient of the 150 patients treated. This local reaction disappeared when the ointment was discontinued for several days and when the ointment was reapplied no further difficulties were encountered.

#### COMMENTS

The addition of 9-aminoacridine (1:500) to allantoin 2 per cent, sulfanilamide 10 per cent in a non-greasy, water-miscible base rendered this combination more effective in the treatment of infected wounds and as a prophylactic measure in clean wounds. It was found to be safe, non-staining and soothing; pain was controlled in a majority of cases shortly following the application of the ointment.

Successful and gratifying results were obtained in 150 representing such conditions as traumatic wounds, postoperative wounds, chronic leg ulcers, decubitus ulcers, second and third degree burns, frostbite and amputation stumps.

Sound surgical judgment and good surgical procedures are of great importance, the allantoin, sulfanilamide, 9-aminoacridine ointment being only an adjunct.

The effectiveness of the allantoin 2 per cent, sulfanilamide 10 per cent, 9-aminoacridine (1:500) ointment was evidenced in the rapidity with which wound infections were controlled, the definite vascularization of granulation tissues and the stimulation of marginal epithelization.



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# PREVENTION OF ADHESIONS IN THE RIGHT COLONIC GUTTER FOLLOWING RIGHT COLONIC RESECTIONS.

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THOMAS E. Jones<sup>1</sup> in an interesting article on colonic resections states; and the post operative convalescence is therefore much smoother.”  
“One of the greatest difficulties in The simple method described below



FIG. 1. Proximal end of the transverse colon brought down to cover the raw surface.

resections of the right colon, particularly in the very obese patient, is peritonealization of the right gutter. Improperly completed it will lead to adhesion and obstruction which is a definite factor in mortality. For several years we have obviated this by the use of a modified Mikulicz pack. It prevents the small intestine from becoming adherent

offers no difficulties whatsoever and is to be preferred, in that it eliminates the bad features of an open packed wound with its discomforts, delayed convalescence and infective and herniating potentialities. Recently, in removing a carcinoma of the cecum and ascending colon it was found impossible to peritonealize an area just

above the cecum and part of the cecal bed. In order to cover this raw surface, the author simply used the transverse colon which was brought down without the slightest tension and required only 1 chromic catgut stitch to hold it in position. However, for obvious reasons it would be advisable to use several stitches to firmly anchor the bowel. It was also found that the transverse colon could easily be brought over in order to cover the entire gutter, should that have been necessary, as evidenced by the ample slack of the transverse colon shown in the upper right hand corner of the picture. In those patients in whom part of the transverse colon runs parallel to the cecum and ascending colon the transverse colon would practically fall into position over the gutter. On the other hand, should the transverse colon be only slightly festooned and densely adherent the ileum which is the gut threatened to become obstructed can be put in the trench in such a manner as to prevent future obstruction. The author believes, however, that in almost every patient the transverse colon can be utilized to cover the gutter.

#### CASE REPORT

The operative procedure described above, aimed at the prevention of adhesions, was

carried out December 11, 1945, on Mrs. F., aged forty-eight, under spinal anesthesia at the Illinois Central Hospital, Chicago. The patient left the hospital on December 26, 1945, in good condition. Re-examination of the patient on February 15, 1946, revealed an expected substantial increase in weight, but more interesting and significant in this particular case was the fact that the bowels had moved throughout without any medicinal aid showing that the displacement of the colon had caused no interference with the propulsion of its contents.

Re-examination April 15, 1946, showed a negative abdomen and continued normal bowel movements.

#### COMMENTS

The open method of end-to-side anastomosis was employed in the above case report, and we attribute the good primary result as mainly due to the careful pre-operative preparation and postoperative care of the patient, having followed the admirable schedule advised and used with such remarkable success by Karl A. Meyer et al.<sup>2</sup>

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# USE OF ADRENALIN TO PROLONG SPINAL ANALGESIA\*

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IN order to prolong spinal analgesia only two alternatives are available, viz., the concentration of the anesthetic drug may be increased to a certain point, beyond which cord damage is imminent; the other method utilizes the more desirable and practical continuous spinal technic.<sup>1</sup> This paper will present a third method, utilizing relatively small amounts of anesthetic mixed with adrenalin which prolongs analgesia even longer than dangerously high anesthetic concentrations and in many cases obviates the time-consuming detail of the continuous spinal technic. The literature on the use of vasoconstrictors to prolong spinal analgesia was recently reviewed by Prickett, Cullen and Gross who also reported the use of adrenalin with procaine.<sup>2</sup>

The 200 patients herein reported were anesthetized with hyperbaric pontocaine-glucose solutions containing varying amounts of 1:1,000 adrenalin. Adrenalin prolonged sensory analgesia almost double the time for pontocaine-glucose without adrenalin. Sensory analgesia was prolonged with dependability while motor relaxation, although prolonged somewhat, was found to be rather unpredictable as to length of time relaxation would persist. Because of the unpredictability of motor relaxation duration, continuous spinal was used in those patients requiring more than two hours, adding adrenalin to the pontocaine-glucose solution so that intervals between subsequent injections were widely spaced, even with extremely small doses. (3 to 6 mg. of pontocaine for upper abdominal surgery, for example.)

Pontocaine solution 1 per cent (20 mg. in 2 cc. ampules) was mixed with glucose, either 5 or 10 per cent, utilizing the following formula: mg. or cc. of pontocaine multiplied by three equals the total volume

of diluted solution to enter the subarachnoid space.\* For example; 8 mg. or .8 cc. of pontocaine multiplied by three equals 2.4 cc. Glucose 5 or 10 per cent is added to the pontocaine in a syringe until it is diluted to 2.4 cc. If 10 mg. or 1.0 cc. of pontocaine is the dose selected, glucose would be added to this solution until the mixture totaled 3 cc. If 12 mg. or 1.2 cc. is the dose, dilution with glucose would bring the total to 3.6 cc., etc.

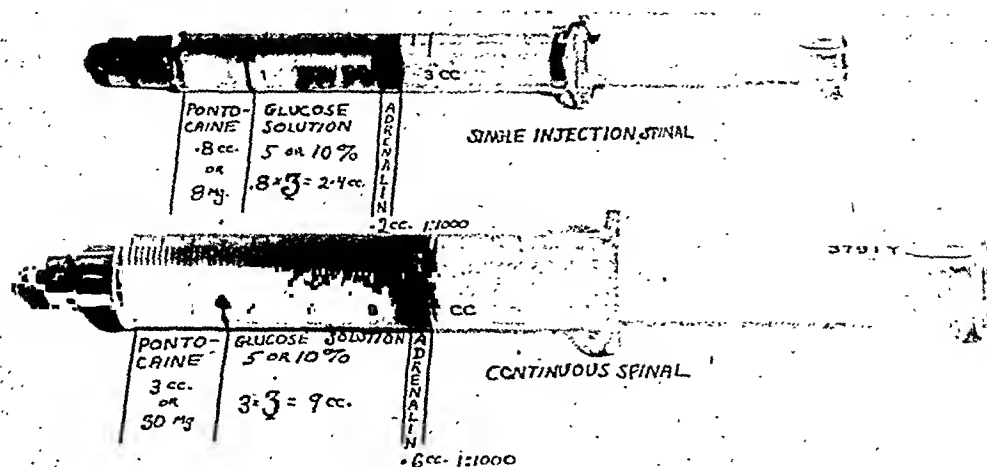
For continuous spinal a 10 cc. syringe is used, into which 30 mg. or 3 cc. of pontocaine is aspirated. This is diluted to 9 cc. with glucose solution. (Fig. 1.) For any single spinal injection, regardless of whether 6, 8, 10 or 12 mg. of pontocaine is used, only .2 cc. of 1:1,000 adrenalin is added to the pontocaine-glucose mixture. For continuous spinal .6 cc. of 1:1,000 adrenalin is added to the 9 cc. mixture of pontocaine-glucose.

## COMMENTS

The average dose of pontocaine rarely exceeded 10 mg. for an adult and was in many cases below 10 mg. The maximum dose was 12 mg. and this figure was never exceeded. There is a very important reason for not exceeding the maximum of 12 mg. When diluted with glucose according to the aforementioned formula, there need be no apprehension with regard to the height of anesthesia reaching the medulla and producing respiratory paralysis or complete upper intercostal paralysis even when the table is placed and permitted to remain constantly in the Trendelenburg position. The reason is that since the medulla is a

\* When using the 2 cc. ampule of 1 per cent pontocaine which contains 20 mg., the number of mg. and cc. are identical when a decimal point is used. For example; 1 mg. = .1 cc., 3 mg. = .3 cc., 10 mg. = 1.0 cc., 12 mg. = 1.2 cc., 20 mg. = 2.0 cc., etc.

\* From the Department of Anesthesiology, South Baltimore General Hospital, Baltimore, Md.



**DILUTION FORMULA FOR SINGLE OR CONTINUOUS SPINAL:**  
 $P \times 3 = T.V.$  (cc. of PONTCAINE  $\times 3$  = TOTAL VOLUME OF PONT-GLUCOSE)

FIG. 1. How pontocaine is diluted with glucose and adrenalin using the dilution factor of 3, which provides the minimum quantity of pontocaine consistent with prolonged motor relaxation.

motor center, by the time the dilute pontocaine-glucose solution reaches this area not only is the pontocaine so diluted in the spinal fluid that it will hardly produce a sensory effect, but motor paralysis is completely obliterated. This is the safety factor in using so dilute a pontocaine-glucose solution as has been described.

Using 10 mg. of pontocaine in glucose *without* adrenalin will produce an average of one and one-half hours of sensory analgesia and from forty-five to sixty minutes of complete motor relaxation. Using 10 mg. of pontocaine in glucose *with* adrenalin will produce an average of three to three and one-half hours of sensory analgesia and from one and one-half to two hours of complete motor relaxation. The addition of more adrenalin, even as much as 1 cc. of 1:1,000, did not prolong analgesia beyond the above stated figures. It would appear that adrenalin exerts its maximum effectiveness in small quantities and will extend the duration of analgesia no further despite increased amounts.

Adrenalin was used with continuous spinal when the initial intrathecal injections were as low as 3 mg. for upper abdominal surgery. This injection had to be repeated, however, about twenty minutes before closure of the peritoneum to assure

complete relaxation. When such small doses as 3 mg. are used for upper abdominal surgery, it becomes necessary to use a steep Trendelenburg position during the injection, as well as for a minimum of five minutes after the injection, in order to assure motor paralysis in the upper border of the incision. For upper abdominal surgery in the average good risk adult, an initial injection of 9 mg. is used when employing the continuous spinal method.

There was no noticeable increase in blood pressure which could be attributed to the adrenalin in the subarachnoid space. The physiological explanation for the prolonging action of adrenalin is probably to be found in its vasoconstrictive properties on the mesothelial resorption tubules in the cord and meninges and on the blood vessels in the same area. There were no more instances of post-spinal headache or other neurological sequelae following spinal with adrenalin than that seen when adrenalin was not used. There were no postoperative complications in the entire series. Post-spinal headaches, pulmonary sequelae and urinary retention were not increased beyond what one would expect in a similar series omitting the adrenalin.

For hemorrhoidectomy under spinal, adrenalin was omitted because operating

time was seldom over twenty minutes and there was no indication for prolonging analgesia unnecessarily.

The addition of adrenalin was felt to be a distinct advantage in continuous spinal especially in poorer risk patients where the very minimum dose of pontocaine would be employed. In these patients it was unnecessary to reinject solutions every thirty minutes to an hour. The sensory effect even in small doses was so greatly prolonged that subsequent injections were required for peritoneal closure only.

Other vasoconstrictors (methedrine, neosynephrine and ephedrine) were used with the pontocaine-glucose solutions but none proved as effectual as adrenalin.

#### CONCLUSION

Spinal analgesia may be safely prolonged by adding small quantities of 1:1,000 adrenalin to intrathecal anesthetic solutions. The prolongation with adrenalin makes it possible to materially reduce the

over-all dose of anesthetic drug entering the subarachnoid space. By using adrenalin small, safe doses of anesthetic solution may be made to exert a longer action than larger doses of the same drug without adrenalin. Larger quantities of adrenalin do not increase analgesic duration beyond that caused by small amounts. With continuous spinal the frequency of subsequent injections was lessened when adrenalin was used. Motor paralysis was prolonged but not as extensively as was sensory analgesia. In addition, motor paralysis was not extended for the same length of time in individuals of the same age and physique. For this reason continuous spinal was used in those patients whose operation might extend over two hours in which profound motor relaxation was a prerequisite.

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# OBSERVATIONS ON EARLY POSTOPERATIVE RISING

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THERE has been a trend sweeping the country during the past few years for surgeons to let their surgical patients up from bed early. The author would like to give here his own clinical observations over a five-year period.

During the past five years the writer has allowed the majority of his postoperative surgical patients to rise early, i.e., on the first or second postoperative day. This procedure was actually started by the patients themselves in a county hospital when they got up of their own accord. The author observed that those patients who did so got along much better and had a much smoother postoperative course than those patients who remained in bed during their entire hospital stay.

The author has gotten approximately four hundred major surgical patients up from bed early and has observed that their postoperative course has been much smoother, they have less postoperative complications, they have fewer gas pains, their elimination is better and their recovery is more rapid. In addition, there is no greater incidence of evisceration or hernial development than with those patients who may remain in bed longer. The writer has also gotten patients with hernias up on the first postoperative day and has seen no recurrences which were referable to their early rising.

There is a great deal said in the literature that patients should be gotten up early only if they have been closed with interrupted cotton or some other non-absorbable suture. For a long time the author believed this but of late he has started getting many patients up (approximately one hundred cases) early on the first and second postoperative days who had been sutured entirely with catgut. (Plain No. 1

for peritoneum, chromic No. 1 for fascia and No. 000 plain for skin.) He has found no greater incidence of wound dehiscence in these cases; on the other hand, he has a case of wound dehiscence in a man seventy years of age with a ruptured ulcer who was debilitated and whose wound was sutured entirely with interrupted cotton sutures. The author believes that wound dehiscence depends to a large extent on the nature and physical condition of the patient at the time of the operation and not on the suture material.

*Types of Cases That Rise Early.* The following are the types of patients who rise early: (1) Hernias of all kinds as well as appendectomies; (2) cesarean sections have gotten up on the second and third postoperative days; (3) gastrectomies and gallbladders as well as all abdominal surgery; (4) Pelvic operations, supravaginal and vaginal hysterectomies. No patient with complications is gotten up early.

*Technic.* The author usually suggests to the patient the day before that he is going to get him up the next day and let him think about it for a day. Also he tells him that the sooner he gets up the sooner he will be able to leave the hospital. Those patients who object are not obliged to get up. The next day the author usually gets the patient up himself and employs the following technic: First, he helps him sit on the edge of the bed; then he assists him into a standing position. Then the writer has the patient take a few deep breaths and cough a few times. If there is anything in the tracheobronchial tree it will be coughed up. The patient then is assisted while he takes several steps. The author usually allows the patient to remain up for ten minutes for the first morning and afternoon and gradually increases the time each day.

*Benefits of Early Rising.* The benefits of early rising are many: (1) Elimination of pain. Almost all surgeons will agree that those patients who do not move around in bed and who splint themselves are the ones who have the most pain. Those who move around a great deal are the ones who will have very little pain; this is especially true of patients who get out of bed early; (2) elimination of gas pains and postoperative ileus. When a patient gets up early he usually belches a few times and gets rid of some gas and from that time on he will have fewer gas pains; (3) a more rapid regain in strength; (4) better function of the bowels and kidneys; (5) less frequency of postoperative embolism; however, one must remember that there are some patients who prior to operation have a quiescent phlebitis of the deep calf veins which may lead to embolism even though one attempts to get patients up early. On the other hand, there is not as much tendency for the development of that type of phlebitis and embolism which occurs in those patients who are kept in bed from seven to fourteen days and have retarded circulation.

As to the fear of some surgeons that there will be more instances of hernia in those patients who get up early, the author would like to state that in his experience he has not seen it occur. There usually are definite causes for postoperative hernia.

#### SUMMARY

1. Early postoperative rising is of great advantage to the early recovery of the patient.
2. Early rising leads to a lower incidence of embolism.
3. It reduces the number of days in the hospital for those who stress an economic viewpoint.
4. Suture material, in the author's experience, actually does not make any difference in the closure and in getting the patient up, whether cotton or catgut is used.
5. There is no greater incidence of hernia as a result of early rising.

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# Case Reports

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## PYLEPHLEBITIS AND PYOGENIC LIVER ABSCESS\*

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THIS report was prompted by the recovery of a clinically diagnosed patient with pylephlebitis and pyogenic liver abscess who responded to penicillin. Since January 1, 1942, the records of Wesley Memorial Hospital reveal only one other such patient. He too was treated with penicillin. The literature reveals five other patients treated with penicillin.<sup>1-5</sup>

It is not our purpose to discuss liver abscess of amebic origin but only pyogenic liver abscess and pylephlebitis. In this connection it should be remembered that, while pylephlebitis is usually associated with multiple pyogenic abscesses of the liver, pyogenic liver abscess is not necessarily associated with pylephlebitis. The two are separate and distinct pathological entities, "which many have come to regard as synonymous."<sup>6</sup> The diagnosis of both conditions is difficult and may be said to rest on the 'suspiciousness' of the diagnostician. The literature is replete with reviews<sup>5-11</sup> and case reports in an attempt to promote earlier diagnosis. The review of Osehner et al.<sup>7</sup> is particularly complete and concise.

The symptoms of pyogenic liver abscess and/or pylephlebitis are fever, chills, right upper quadrant pain which may radiate to the shoulder, sweating, malaise, severe dull headache, weakness, anorexia, loss of weight, jaundice, dyspnea and the absence of nausea and vomiting.<sup>7-10</sup> All of these symptoms are usually pronounced at some time during the course of the diseases although chronic liver abscess may be puzzling because of the relative mildness of the symptoms.

The signs usually include right upper quadrant tenderness, rigidity, hepatomegaly, splenomegaly, a fixed high diaphragm and an absent gas shadow under the diaphragm in the x-ray. Ascites is a rare and late manifestation in the course of either disease.

Diagnostic procedures include peritoneoscopy, aspiration and intravenous thorotrast<sup>1,15</sup> coupled with x-ray of the liver and spleen. Each has its limitations and dangers. Leukocytosis above 15,000 is usually present but may be lower in chronic liver abscess. Blood culture is usually negative.

### CASE REPORTS

CASE 1. A male, aged forty-six, was admitted to Alexian Brothers' Hospital November 11, 1944, because of continuous fever following a cold two weeks previously. Four days prior to admission he had a severe chill with fever plus pain in the left chest. The presenting complaints were fever, general weakness and aches, headache and anorexia. His general condition was good.

A physical examination revealed the following: temperature 102°F., pulse 84, respirations 18, blood pressure 120/60. There were râles in the left mid-lung fields anteriorly and posteriorly but there were no other abnormal findings. The urinalysis revealed that the specific gravity was 1.020, with a trace of albumin and 20 to 25 leukocytes. The Kahn test was negative. The erythrocyte count was 4,810,000, hemoglobin 92 per cent, leukocyte count 9,200 with 80 per cent polymorphonuclear cells.

Because of clubbing of the fingers, palpable splenomegaly, soft apical systolic murmur, fever and chills, subacute bacterial endocarditis

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was considered the most likely diagnosis in January, 1945. A chill on January 13th, was followed by a temperature of 104°F. and severe abdominal pain. Shortly thereafter a few râles were heard in the right lower and mid-lung fields. The patient complained of insomnia,

50 pounds. Profuse sweating and marked weakness were present. The tongue was atrophic. The chest was barrel-shaped, had a limited expansion and there were dullness and diminution of fremitus and breath sounds in the lower chest bilaterally. A few moist râles were heard

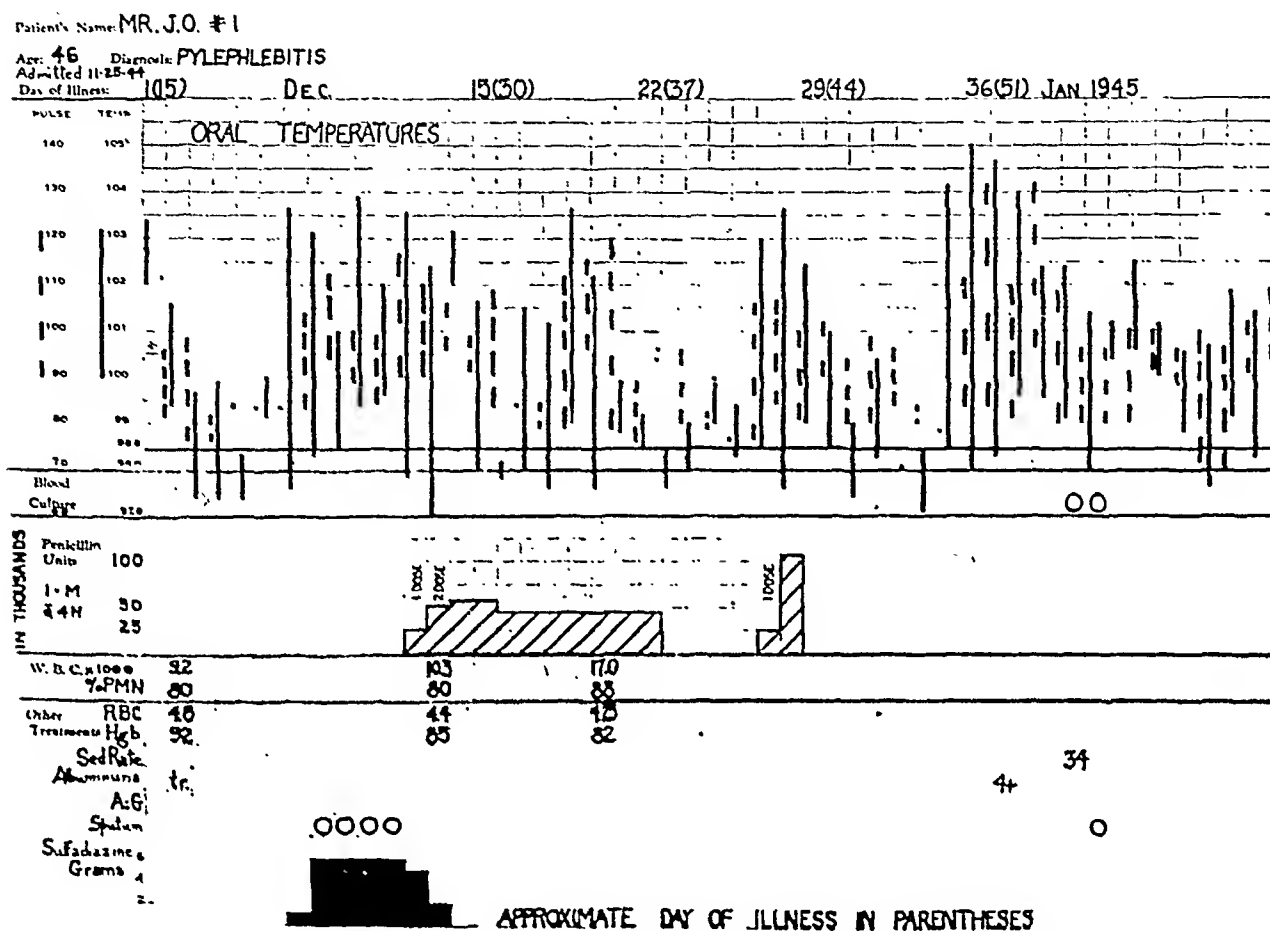


FIG. 1. Mr. J. O. pylephlebitis. For convenience hiatus appears between eighty-eighth and 116th days.

dyspnea and pain in both splenic and right upper quadrant areas. Laboratory studies at that time revealed progressive anemia, sputa negative for tubercle bacilli, normal chest film, negative blood culture, normal albumin-globulin ratio, persistent leukocytosis and albuminuria, negative reactions for the typhoid, paratyphoid, dysentery and brucella groups and a ptosed right kidney with a normal intravenous pyelogram. The sedimentation rate was 34 mm.

He was transferred to Wesley Memorial Hospital on January 20th, at which time he was emaciated, acutely ill, occasionally incoherent and unable to give an adequate history. He appeared about sixty years of age.

His temperature was 99°F., pulse 108, respirations 18 and blood pressure 104/72. It was estimated that he had lost between 30 and

in the left mid-lung posteriorly. A faint apical systolic murmur was heard. The abdomen was moderately distended, tympanitic, generally tender and spastic. The spleen was palpable. The liver was felt three fingerbreadths below the costal margin. No embolic phenomena or petechiae were noted.

The urine showed a specific gravity of 1.015, slight trace of albumin and an occasional leukocyte. The erythrocyte count was 2,920,000, hemoglobin 10 Gm. The leukocyte count was 13,350 with 81 per cent polymorphonuclears. The sedimentation rate was 35.5 mm. in forty-five minutes. The icterus index was 18.2 and the blood non-protein nitrogen 23.1 mgm. per cent, CO<sub>2</sub> combining power 40.5 volume per cent, albumin-globulin ratio 3.12:3.48, coagulation time 4.5 minutes (normal being 8 to 10) and the bleeding time was four minutes. The electro-



thrombus. A moderately thickened gallbladder with almost complete destruction of the mucosa was present. The spleen weighed 440 Gm. and was friable. The pleural cavities were free of fluid and adhesions. The left lung was adherent to the diaphragm.

tion because of a peptic ulcer. Operation on September 24, 1945, was uneventful as was the immediate postoperative course. On October 5th, she complained of back pain and malaise. Two days later she vomited bile and the next day passed a gray stool. On the nineteenth post-

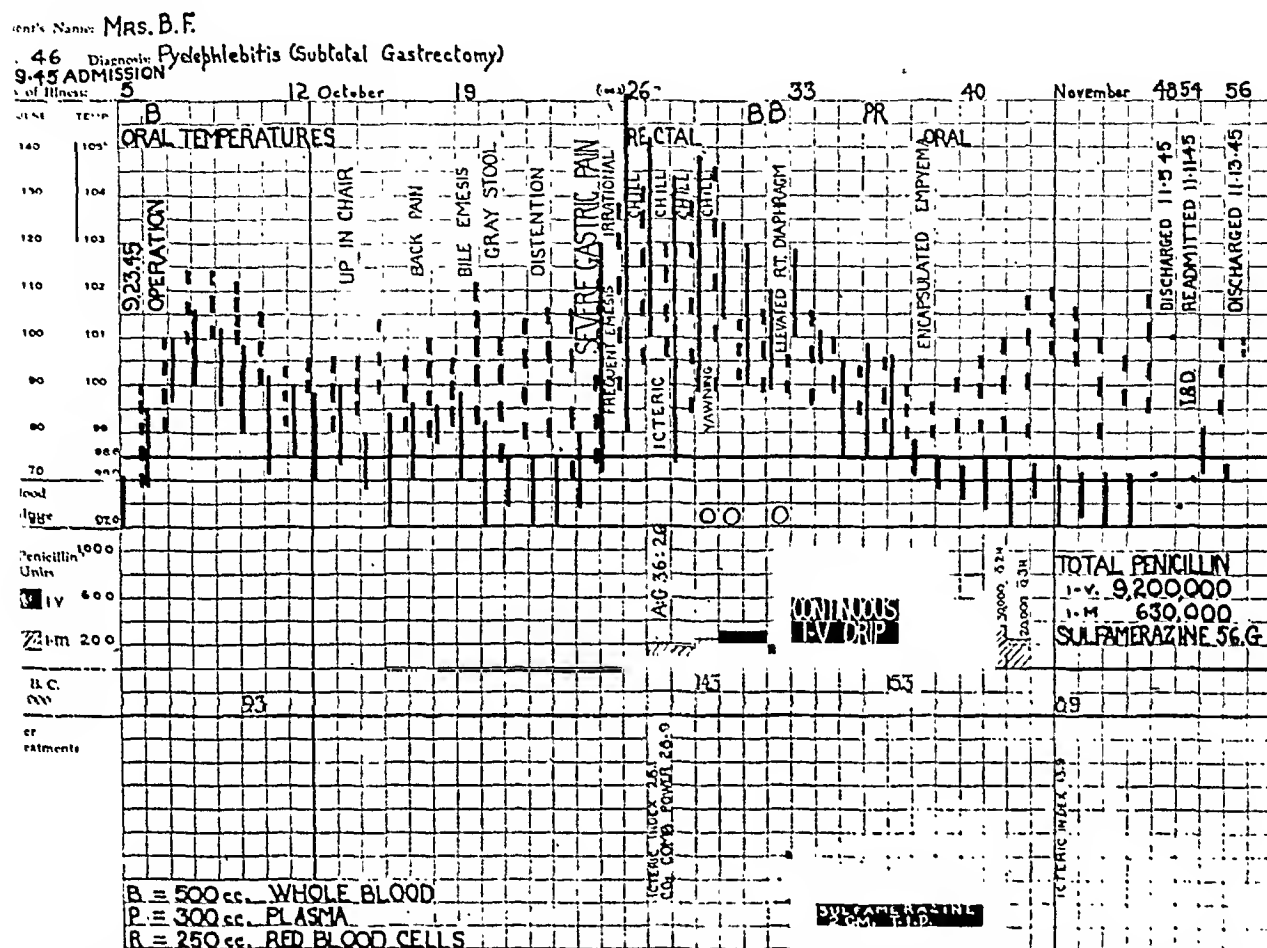


FIG. 3. Mrs. B. F., pyelphlebitis (subtotal gastrectomy). The patient was at home between the forty-eighth and fifty-fourth days. Total penicillin dosage was 328,000 units intramuscularly and 6,500,000 units intravenously.

On microscopic section the liver was markedly congested. The stroma of the portal canals was densely fibrotic. Multiple abscesses were present, the fibrotic walls of which were lined by membranes of cellular debris or densely infiltrated with plasma cells or lymphocytes. The wall of the small bowel was fibrosed and the serosa irregularly thickened. Marked fibrosis of the spleen and marked thickening of the capsule were present. In the opinion of the pathologist the liver abscesses apparently resulted from infection of the small bowel. No other specific lesions could be demonstrated. Cultures of the liver abscesses and of the ascitic fluid revealed *Escherichia coli*.

CASE II. Mrs. B. F., aged forty-six, a housewife, was admitted for subtotal gastric resec-

operative day there was severe pain in the hypochondrium as well as abdominal distention. The next day the temperature rose to 103°F. and she was irrational and vomited frequently. During the four succeeding days there were frequent chills and rises in temperature, reaching 106.2°F. rectally. Jaundice developed. On the day following the first temperature rise, 100,000 units of penicillin were given by continuous intravenous drip and the next day this was supplemented by 12,500 units every three hours by intramuscular injection. After two days this was increased to 300,000 units per day by continuous intravenous drip without appreciable effect on the clinical course. Upon increasing the daily penicillin dosage to 1,000,000 units by continuous intravenous drip there

was almost immediate improvement. In six days the temperature was normal but an x-ray of the chest showed encapsulated fluid, which had been detected clinically two days previously. Aspiration was not performed. Recovery proceeded rapidly and she was discharged on the forty-second postoperative day. Six days later she returned for incision and drainage of an abscess which had pointed through the abdominal wall in the supra-umbilical region. Cultures of the pus from this abscess failed to show growth under aerobic and anaerobic conditions. She was discharged November 11, 1945. At the time of the last examination, March 1, 1946, she was well, active and performing most of her duties as a housewife, complaining only of slight fatiguability.

Figures 1, 2 and 3 outline the treatment and course. For brevity, hiatus appear between the eighty-eighth and one hundred sixteenth days of Case 1 and the forty-eighth and fifty-fourth days of Case 11.

#### COMMENTS

Prior to this time the mortality rate in liver abscess and/or pyelphlebitis has been between 90 per cent and 100 per cent if surgical intervention were not feasible. With surgery the mortality rate has been between 33 per cent and 73 per cent,<sup>12</sup> depending on the route of surgical approach. Complications and multiplicity of abscesses increase the mortality rate.<sup>6,8,12</sup> If abscesses result from cholangitis, drainage can be adequate; otherwise it is not adequate.<sup>9</sup> Parahepatic abscesses are more amenable to surgery with consequent lower mortality rate. The outlook is always grave and prognosis should be guarded.

It is much too early to say what rôle penicillin will play in reducing the mortality rate in these diseases. An insufficient number of patients have been treated. Only five previous case reports were found in the literature. Yater<sup>1</sup> gave his patient only a total of 150,000 units without success. An autopsy was not performed. Sheridan<sup>2</sup> was dealing with a patient with Friedländer's bacillus which is known to be penicillin insensitive. Fish and Conrad<sup>3</sup> were treating a patient with a secondarily

infected amebic abscess and used penicillin as an adjuvant to other therapeutic measures. Gonzalez and Vejar<sup>4</sup> used penicillin on a patient with complicated symptoms when all other methods failed. They began with 30,000 units intramuscularly every three hours and gradually decreased the dose and frequency. A total of 2,721,000 units was given over a period of eighteen days. This patient recovered. Flynn<sup>5</sup> gave his subject 20,000 units every three hours for three weeks postoperatively but the patient had surgical drainage for abscess following acute cholangitis and recovered. However, this recovery must be attributed to surgical intervention.

Case 1 should not be considered as a penicillin failure. The diagnosis was not made antemortem. The causative organism, *Escherichia coli*, is penicillin-resistant. Unfortunately, in pyogenic liver abscess and pyelphlebitis the blood culture is so often negative and aspiration which might help in isolating the offending organism is so dangerous, that it is usually impossible to determine whether or not one is dealing with a penicillin-sensitive organism. Since some strains of *Escherichia coli* are inhibited by high concentrations of penicillin and since it is difficult to determine the causative organism in these diseases, we believe that large doses of penicillin are indicated in all patients not amenable to surgery.

The massive penicillin dosage which we have employed in subacute bacterial endocarditis<sup>16,17</sup> influenced us in treating Case 11. Apparently, a very high blood penicillin level is necessary to inhibit growth of organisms enmeshed in fibrin as is the case in subacute bacterial endocarditis. In order to attain an effective level within an hepatic abscess, equally high or higher blood levels may be necessary. Knowing that a daily dose of 300,000 units is inadequate for the cure of most cases of endocarditis, we advised increasing the daily dose in Case 11 to 1,000,000 units, because signs and symptoms were still acute although the temperature had started

to fall. We were also attempting to profit by the experience in Case 1 in which 500,000 units per day for ten days were inadequate. If the *Escherichia coli* present at autopsy were not a postmortem invader, it is possible that no amount of penicillin would have availed. If, however, the original organism had been something else, then the small doses of penicillin used prior to the 500,000 units might have increased its resistance to the point where the moderately large daily dose of 500,000 units was inadequate.

There may be a question in the diagnosis of Case 11. However, in the presence of severe chills and fever, jaundice, extreme morbidity, absence of subdiaphragmatic or subhepatic gas shadow in the x-ray and with a negative blood culture we have to doubt that this was a parahepatic abscess. We believe that the abdominal abscess which developed later represents a complication, either a contiguous infection of the subdiaphragmatic space or rupture of a surface liver abscess into this space. It is of great surgical interest to note that the literature fails to reveal reports of such abscesses which, as happened in Case 11, found its way between the folds of the ligamentum falciformis and became an abscess necessitans. A simple incision just above the umbilicus, resulting in evacuation of a large amount of sterile material, relieved the patient of all symptoms.

#### SUMMARY

Two patients with pyogenic liver abscesses and pyelephlebitis, one proven by autopsy and the other diagnosed clinically, are presented. One patient recovered after a total dose of 9,830,000 units of penicillin, of which 7,000,000 units were given by continuous intravenous drip at the rate of 1,000,000 units per day. If surgical inter-

vention is not feasible, the use of penicillin in this, or even larger doses, is suggested as a possible life saving measure.

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# TREATMENT OF CHRONIC SALPINGITIS WITH BENZYL CINNAMATE ESTER (JACOBSON'S SOLUTION)\*

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THIS preliminary report covers thirty cases of chronic salpingitis in which the patients were treated with benzyl cinnamate ester (Jacobson's solution). As far as is known, this therapy is the first of its type employed in this country. Jacobson's solution is a 4.1 per cent of inter-reaction product of benzyl cinnamate and its decomposed radicals in the form of ethyl cinnamate ester and benzyl alcohol dissolved in olive oil.

This drug was introduced and presented by Jacobson in Paris in 1929<sup>1</sup> in the treatment of chronic inflammatory lesions regardless of their localization and pathogenic agents responsible for these lesions. Jacobson studied the biological properties of benzyl cinnamate. The ability of this preparation to inhibit the development of certain microbic agents, to neutralize the toxins *in vitro*, to produce leukocytosis<sup>2</sup> and to provoke a generalized vasodilatation may suggest hypotheses on its mode of action.

What appears to be certain is the vascular reaction, which Jacobson observed and described, on the corneal opacities provoked experimentally on animals prior to treatment with benzyl cinnamate solution. This vascular reaction is temporary. It is characterized by a dilatation of the existing vessels, by an opening of the blocked vessels and by the appearance of newly formed vessels.<sup>3</sup> Clinically and experimentally, it has been observed that Jacobson's solution advantageously modifies chronic inflammatory lesions (produced by various pathogenic agents) by absorbing necrotic tissues and by activating the cicatrization of ulcers.<sup>1</sup>

In 1929, Jacobson suggested that since benzyl cinnamate ester advantageously

lessens the severity of chronic inflammatory lesions, the pain at the site of the lesion might be relieved. The inflamed tissue causes irritation and compression of the nerve endings at the site of the lesion. Therefore, when the inflamed tissues regress under the action of this medication, the pain is diminished and symptoms relieved. Jacobson strongly supported this interpretation by working with chronic salpingitis in which there is, at the same time, both subjective pain and an inflammatory lesion which can be demonstrated by palpation. The good results obtained in this condition with benzyl cinnamate ester were confirmed by Levy-Solal, Jacobson, Delsace and Pariente, who treated chronic salpingitis refractory to previous clinical treatment.<sup>4</sup>

These authors noted that the pain usually disappears after five or six injections. This is particularly observed where the pain is continuous. The lesion itself, which can be studied by palpation, regresses by degrees. At the beginning, the adnexal mass becomes more delineated, due to the surrounding tissue becoming smooth and free from infiltration and compression. The mass is then noted to be of a soft consistency. Part of it is absorbed and the remaining mass replaced by a fibrotic-like tissue. There are also cases in which the masses have completely resolved under treatment with Jacobson's solution.

*Method of Treatment.* The patient receives a series of twelve intramuscular injections of 1 cc. each daily. A rest period of ten to fifteen days is indicated before repeating this procedure. A total of twelve to thirty-six injections may be given, depending upon the nature and severity of the lesion.

\* From the Out-Patient Clinic of the Department of Gynecology, Harlem Hospital, service of Dr. Henry C. Falk.



## CASE REPORTS

CASE I. No. 41-2520, P. M., aged twenty-six, complained of bilateral abdominal pain accompanied by vaginal discharge on March 20, 1946. Bimanual vaginal examination revealed tenderness and thickening of both adnexal regions. A series of twelve injections of benzyl cinnamate (Jacobson's solution) was given over a period of five weeks, and on April 30, 1946, the patient stated that she had no pain since the eighth injection. Bimanual vaginal examination on this date revealed no adnexal disorder.

CASE II. No. 46-7526, C. M., aged twenty-two, on April 1, 1946, stated that she had bilateral abdominal pain which was intermittent for one year, becoming very severe two days previous. Upon examination the right adnexa showed a 4 by 4 cm. mass with marked tenderness; the left adnexa showed only marked tenderness and no masses. A series of twelve injections were given and on April 25, 1946, the patient stated that she had no pain since the fifth injection. An examination proved the right ovary to be palpable, with no tenderness, and a 3 by 2 cm. mass; the left fornix was negative.

CASE III. No. 45-4025, E. G., aged twenty-two, was being treated for syphilis. On March 19, 1946, she complained of soreness in the lower abdomen. An examination showed the adnexa to be bilaterally tender and thickened. On April 22, 1946, after a series of twelve injections the patient noted that she was free from pain since the eighth injection. An examination showed the right fornix to be negative, the left fornix revealed a 5 cm. non-tender mass.

CASE IV. No. 46-7229, E. M., aged nineteen, on March 26, 1946, complained of bilateral abdominal pain with a moderately thick, white vaginal discharge. Upon examination the adnexa were bilaterally tender; the left salpinx was palpable, thick and tender. On April 25, 1946, after a series of twelve injections examination revealed the right fornix to be normal; the left showed slight fullness but no tenderness.

CASE V. No. 45-518, M. O., aged nineteen, on March 25, 1946, complained of lower left abdominal pain after receiving sulfonamide and penicillin therapy for five weeks in the hospital. Upon examination the left adnexa was found to be tender and thickened. On April 22, 1946, after a series of twelve injections, the patient stated that she was free from

pain since the third injection and was able to continue housework. On final examination the right fornix was normal; the left fornix showed no tenderness with a 4 cm. mass to the left of the uterus.

CASE VI. No. 46-7090, K. P., aged twenty-four, on March 19, 1946, complained of pain in both lower quadrants, which had become progressively worse in the past two weeks accompanied by marked vaginal discharge. Examination showed a large tender mass, right adnexa. After a series of twelve injections, the patient reported that the discharge diminished after the sixth injection, and that she had a general feeling of well being since the fourth injection. A final examination showed the adnexa to be normal and the ovaries palpable.

CASE VII. No. 45-14926, J. S., aged twenty-six, on March 22, 1946, complained of lower abdominal pain, cramp-like in nature, with marked vaginal discharge. Right salpingectomy had been performed four months previously. Upon examination the left adnexa proved to have a large tender mass. On April 24, 1946, after the twelve injections were given the patient stated that after the first and fourth injections she had headaches. After the fifth injection pain in the abdomen diminished. After the sixth injection the patient said she was free from pain. Upon final examination the left fornix was shortened, with a 4 by 4 cm. mass in the left cul-de-sac and no tenderness.

CASE VIII. No. 46-7227, D. S., aged twenty-six, on March 25, 1946, complained of pain in the lower left quadrant for a period of two years, also a white mucous discharge for the past eight months. An examination revealed ropey tender masses in both fronices. On April 23, 1946, after the twelve injections the patient was free from pain and from vaginal discharge. Final examination showed the right adnexa to be ropey, palpable, with no tenderness; the left adnexa showed no masses and no tenderness.

CASE IX. No. 46-7215, H. A., aged twenty-two, on March 25, 1946, complained of pain in the lower left quadrant, with profuse, white, watery discharge. An examination showed the right adnexa to be tender, and the left to be tender with a small mass. On April 22, 1946, after a series of twelve injections, the patient stated that she had been free from pain since the fourth injection. Final examination showed the ovaries palpable and small; no other masses and no tenderness were present.



CASE X. No. 46-7260, A. B., aged twenty, on April 1, 1946, complained of lower bilateral abdominal pain with the pain in the left side more severe, also vaginal discharge. Upon examination the right adnexa was found to have a 5 cm. mass, the left tender and full. On April 25, 1946, after a series of twelve injections, the patient stated she was free from all pain after the tenth injection. A final examination showed the left fornix to have no tenderness, no palpable disorder and the right fornix to be shortened.

CASE XI. No. 44-7058, L. S., aged twenty-six, on March 2, 1946, complained of pain in both lower quadrants. The patient was hospitalized a year ago and was told that surgery was indicated, but refused. An examination showed the adnexa to have bilateral tenderness and a tender mass in the right cul-de-sac. On April 29, 1946, after the series of twelve injections, the patient stated that she felt better since the third injection and is free from all pain at the present. A final examination showed the left fornix to be normal; in the cul-de-sac and right fornix a 4 by 2 cm. mass was present with no tenderness. Treatment was continued.

CASE XII. No. 44-6371, E. G., aged twenty-four, on March 22, 1946, complained of bilateral lower abdominal pain. She aborted on December 13, 1945, and was admitted to the hospital in January, 1946. There she was operated upon for an "abscess between uterus and vagina." She had been treated previously with foreign protein for a similar condition. An examination showed bilateral tube-ovarian inflammation. On April 25, 1946, after the sixth injection the patient stated she had been free from pain but did not return for further treatment.

CASE XIII. No. 46-3293, H. D., aged twenty, on March 22, 1946, complained of bilateral pain of the lower abdomen. This patient received foreign protein therapy without relief. An examination showed a 6 by 4 cm. mass in the right adnexa and tenderness in the left adnexa. On April 23, 1946, after the third injection the patient stated that she had some relief after the third injection and that she was free from all pain at that time. She did not return for further examination or treatment.

CASE XIV. No. 46-1145, H. M., aged twenty-two, on March 26, 1946, complained of having abdominal pain all day and distention at night, present for about a year. An examina-

tion showed the left adnexa to have a tender mass. On April 25, 1946, after a series of twelve injections the patient claimed that the pain in the abdomen was not severe since the ninth injection, and that she was free from pain since the eleventh injection. An examination showed the ovary to be tender on the left side. Treatment was continued.

CASE XV. No. 45-10301, J. B., aged twenty-one, on March 19, 1946, complained of lower abdominal pain on both sides with the pain on the right side very severe. The pains had become progressively worse for the past three years. An examination showed tenderness in the adnexa with thickening. Tenderness was also found in the equigastrium and descending colon. On April 25, 1946, after a series of twelve injections the patient stated that she had been free from all pain since the eighth injection. An examination showed a tender ovary on the left side. Treatment was continued.

CASE XVI. No. 45-14568, A. L., aged twenty-three, on March 26, 1946, complained of having lower abdominal pain for four months. She also stated that she was treated elsewhere without improvement. An examination showed the right adnexa to have a large tender mass. On May 2, 1946, after the series of twelve injections the patient reported feeling better since the ninth injection. An examination showed the right fornix to have a 2 by 3 cm. mass with slight tenderness. The left fornix was shortened with no tenderness. Treatment was continued.

CASE XVII. No. 46-7257, O. S., aged twenty-five, on April 1, 1946 the patient complained of bilateral lower abdominal pain, also of pain on urination. For several days the patient also had been running a temperature. Examination showed the right adnexa to be tender and full; the left was tender with a 4 cm. mass. After three injections the patient stated she still had pain and did not return for further treatment.

CASE XVIII. No. 46-8111, S. S., aged twenty, on March 29, 1946, complained of a sharp and constant pain in the lower abdomen since January, 1945. An examination showed a large tender, fluctuant mass. Surgery was suggested prior to the therapy but the patient refused. On April 29, 1946, after a series of ten injections, the patient stated that the pain was intermittent but felt better after the tenth

injection, and did not return for further treatment.

CASE XIX. No. 45-4183, B. M., aged twenty-one, on March 25, 1946, complained of pain in the lower abdomen radiating to the back. An examination showed the right and left adnexa to be palpable and tender. On April 23, 1946, after the sixth injection the patient reported that she was pregnant (?) and did not return for further treatment.

CASE XX. No. 46-7119, K. L., aged twenty-three, on March 22, 1946, complained of lower abdominal pain which was more severe on the left side. An examination of the abdomen showed tenderness of both lower quadrants, the cervix was soft and tender. Masses were felt in the right and left adnexal regions. On April 2, 1946, after the patient received six injections, she stated she was free from all pain and did not return for further treatment.

CASE XXI. No. 46-3732, F. H., aged nineteen, on April 16, 1946, complained of lower abdominal pain present for two and one-half months. An examination of the right and left adnexa showed them to be tender with ropey masses. On April 18, 1946, after two injections the patient said that she felt better and did not return for treatment.

CASE XXII. No. 46-7719, M. G., aged twenty-one, on March 26, 1946, complained of bilateral abdominal pain with vaginal discharge for about one year. An examination showed a ropey mass in the right adnexa. On April 9, 1946, after receiving two injections the patient did not return for further treatment.

CASE XXIII. No. 42-27340, F. G., aged thirty-two, on March 26, 1946, complained of intermittent pain in both lower quadrants. The pain had been present for two years since the birth of her last child and had become steadily worse. An examination showed the right adnexa to have a large mass. On April 18, 1946, six injections had been given when the patient complained of pricking sensation after the third injection, but stated that she was free from all pain since the sixth injection. She did not return for further treatment.

CASE XXIV. No. 45-2510, C. S., aged forty-six, on March 14, 1946, complained of pain in the left abdomen since February, 1946. She was hospitalized eight months previously for severe abdominal pain. She also had profuse vaginal discharge. Examination showed both

adnexa to be full and tender; there was also tenderness in both lower abdominal quadrants. On March 17, 1946, after three injections the patient said she felt better and did not return for further treatment.

CASE XXV. No. 46-7118, M. W., aged nineteen, on March 22, 1946, complained of pain in the lower right side. The pain was constant and at times more severe than others. A vaginal discharge was also present. An examination showed a tender mass in the right adnexa. The left adnexa was negative. On March 26, 1946, after three injections were given the patient stated that she had some relief and did not return for further treatment.

CASE XXVI. No. 45-12799, M. F., aged twenty-three, on March 19, 1946, complained of pain in the lower abdomen, which was more severe on the left side. An examination showed the right adnexa to have a 4 cm. tender mass and the left adnexa to be tender. On March 28, 1946, after receiving two injections the patient did not return for further treatment.

CASE XXVII. No. 46-2528, C. W., aged nineteen, on March 26, 1946, complained of a lower abdominal pain. The patient had received four injections of aolan and pain still persisted. An examination showed the left adnexa to have a tender mass. After the third injection the patient stated that she felt better and did not return for further treatment.

CASE XXVIII. No. 43-6927, V. C., aged thirty-nine, on March 19, 1946, complained of lower left abdominal pain with burning on urination. An examination showed the adnexa to have bilateral tenderness and thickening. The patient received one injection and did not return for treatment.

#### SUMMARY

The thirty patients treated can be divided into the following categories: (1) Thirteen patients received twelve injections\* and stated they were free from pain. Local examination showed partial or total regression of lesions. (2) Two patients continued treatment after twelve injections and stated pain was relieved. Local examination showed partial regression of lesions. (3) Three patients received from one to two injections and did not return

\*The materials used in this study were supplied through the courtesy of E. Fougere & Co., Inc.

for further treatment and did not state any change in condition. (4) One patient received two injections and stated no improvement. She did not return. (5) Eleven patients received less than twelve injections, stated they were relieved from pain and did not return.

The authors believe, because of the results obtained a further study is indicated with this safe, painless method of therapy which does not require hospitaliza-

tion or interruption of daily duties. Continued observations are being conducted and a more comprehensive report will be available.

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CHRONIC interstitial salpingitis is characterized by enlargement of the tube, whole walls are thickened and often of gnarled appearance. The fimbriated extremity may be closed and bulbous, or it may be partially patent. Surface adhesions, either light or dense, to surrounding organs are almost always present.

From "Textbook of Gynecology" by Emil Novak (The Williams & Wilkins Company).

## MEDIASTINAL TUMOR\*

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**M**EDIASTINAL tumors and cysts are not uncommon. Since the advent of modern chest surgery increasing numbers of patients are being successfully cared for. The purpose of this paper is to discuss briefly the possible origin of these tumors, the types which may occur, the symptoms and signs that they usually produce, methods of diagnosis and the treatment employed in their eradication. In addition, we are reporting two cases of mediastinal teratoma, one of which is unusual because of its enormous size and the multiplicity of its component tissues.

Heuer states that up to January, 1926, 135 dermoid cysts and teratomas had been reported. He believes their origin to be due to ectodermal displacements or abnormal cells of branchiogenic origin drawn into the chest by the descent of the heart. Many other theories have been advanced to explain the presence of teratomas.

Teratology is a subdivision of embryology that deals with abnormal development and its end products—anomalies. While it is certainly true that not all teratomas are examples of monsters, yet a great proportion probably are. Identical or duplicate twins are really an example of teratoma. They develop from a single egg whereby each member acquires precisely the same chromosomal heritage and hence the same genetic constitution. If they are the same size and completely separate, they form two normal individuals. Identical twins may be a double monster when conjoined and this connection may take place anywhere in the body. If they are joined in the thorax, they are called thoracopagus, sternopagus or xiphopagus. Sometimes they are not the same size and in such instances the larger is known as the auto-

site, the smaller the parasite. The latter may be almost a completely developed included twin—fetus in fetu—which grades down into the teratomas that contain disorderly assortments of tissues or organs.

Other theories include the idea that there is an arrest of certain blastomeres which subsequently undergo a partial fulfillment of their primitive development potentialities; Cohnheim's theory of cell rests which later for unknown reasons begin to grow, and lastly the unproved concept of parthenogenesis of ovarian eggs.

### TYPES OF MEDIASTINAL TUMORS

The mediastinum is a fertile ground for tumors and cysts. This is due to the complexity of its development and its component tissues. The following is a useful, but by no means exhaustive classification of these abnormalities:

- A. Neoplasms and hyperplasias of the thyroid and parathyroid glands
- B. Neoplasms and hyperplasia of the thymus
- C. Neoplasms of nervous tissue:
  - (a) Sympathicoblastoma
  - (b) Hour-glass tumors
  - (c) Neurofibroma, neurolemmoma, neuroma ganglionare
- D. Connective tissue neoplasms:
  - (a) Lipoma
  - (b) Fibroma
  - (c) Chondroma
  - (d) Myxoma
  - (e) Xanthoma
  - (f) Sarcoma
- E. Tracheal and esophageal neoplasms
- F. Tumors of lymph nodes:
  - (a) Acute inflammations; tuberculosis (cold abscess)

\* From the Surgical Service, Indianapolis City Hospital and the Department of Surgery, Indiana University Medical Center.

- (b) Lymphoblastomas:
  - (1) Hodgkin's disease
  - (2) Leukemia
  - (3) Lymphosarcoma
- (c) Endothelioma
- (d) Metastatic carcinoma
- G. Cystic tumors:
  - (a) Epidermoid
  - (b) Bronchogenic
  - (c) Gastrogenic
  - (d) Lymphangiomatous
  - (e) Venous
  - (f) Pericardial
  - (g) Pleural
  - (h) Mixed (dermoid)
  - (i) Ecchinococcus
  - (j) Branchial
  - (k) Duplication of esophagus
  - (l) Undetermined
- H. Vascular tumors:
  - (a) Aneurysm of aorta
  - (b) Aneurysm of heart
- I. Tumors of pericardium and heart; pericardial cysts; diverticula of pericardium

#### SYMPTOMS AND SIGNS

The behavior of teratomas is erratic and variable. They may grow or remain quiescent for years. Most observers believe that they grow as the child grows, and that they cease growing after maturity barring complications which would increase their size such as trauma, infection or malignant change. Malignant degeneration is uncommon. Heuer states that the largest tumor reported was 15 by 11 by 9 cm. (Smith and Stone). Schneider's case was 45 cm. in circumference. In sixty cases of dermoids and teratomas only seven were the latter. The first tumor we are reporting seems to have grown as the child grew. Its size is perhaps one of the largest on record, measuring  $20\frac{3}{4}$  by  $20\frac{1}{2}$  by 9 cm. The second was discovered early in life and was therefore relatively small.

The symptoms and signs are due mainly to the increase in mediastinal pressure but also to displacements of organs. The former interferes with the return of blood through the superior vena cava and may cause

cyanosis, orthopnea, dilation of the superficial veins of the thorax, pulmonary edema, pleural and pericardial effusions. If the obstruction is above the azygos vein, the symptoms are less severe. If below and if the pressure is great, there may be subcutaneous edema of the head, neck, and upper part of the thorax, headache, vertigo, deafness, epistaxis, tinnitus and even convulsions.

Posterior mediastinal tumors such as ganglioneuromas are apt to interfere with the function of the cervical sympathetics producing Horner's syndrome.

By far the most common symptoms of dermoids and teratomas are the persistent cough with or without hemoptysis and dyspnea, which is especially pronounced on the slightest exertion. There may also be dysphagia or regurgitation, hematemesis and recurrent attacks of asthma or pneumonia. Occasionally a patient with a mediastinal dermoid will cough up hair. This symptom is diagnostic.

The size of the growth usually displaces the lung and heart so that there is absolute flatness on percussion and heart sounds and breath sounds are absent or only faintly heard over the affected side. Sometimes there are no symptoms and the growth is discovered by routine x-ray examination as in our second case.

#### DIAGNOSIS AND TREATMENT

The diagnosis of mediastinal growths is made by the history, physical examination, x-ray films made in the anteroposterior, lateral and oblique positions, fluoroscopic studies; bronchography, partial pneumothorax and thoracentesis. Roentgenographic studies are indispensable, not only for diagnosis but for position and behavior fluoroscopically. In general, the roentgenologist will note the following characteristics:

1. *Position.* He will note if in the anterior mediastinum the tumor is usually a dermoid or teratoma; the middle mediastinum, a lymphoblastoma, and the posterior mediastinum a neurofibroma or other nerve tissue growth. Therefore, the position

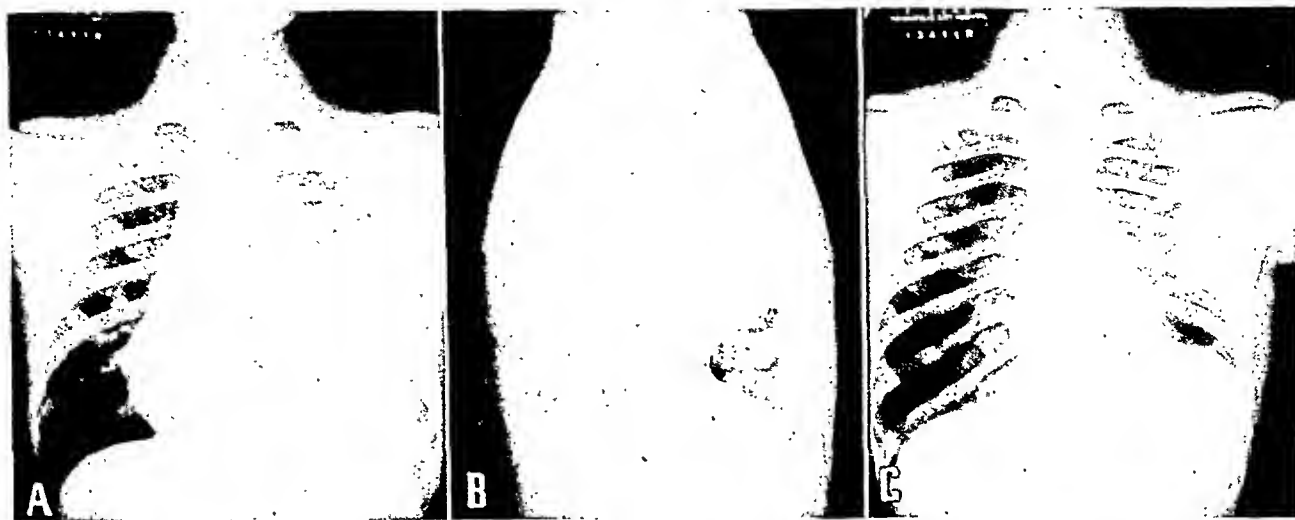


FIG. 1. Case 1. A, x-ray picture of chest prior to operation. Note that almost the entire left chest is occupied by neoplasm; B, lateral view; C, postoperative x-ray picture showing re-expansion of left lung.

is a clue to diagnosis. Moreover, it is important in determining the surgical approach. If it is cervical and retrosternal, presenting at the base of the neck, the cervical route or the cervical with division or resection of the superior portion of the sternum is the most direct avenue to the growth. If retrosternal, not extending beyond the mediastinum, access to the growth may be obtained through a trap-door incision, transverse sternotomy, or median and vertical sternotomy which may be superior, inferior, or which may transverse the entire length of the sternum. If the neoplasm is mediastino-thoracic extending into either thoracic cavity or if it is in a lateral thoracic position, a transpleural approach is best. Posterior neoplasms may usually be removed extrapleurally by resecting the overlying ribs; sometimes laminectomy must be done in removing hour-glass tumors.

2. The presence of shadows indicating teeth or bone leads to the diagnosis of dermoid or teratoma.

3. The spine may show evidence of compression. This with the larger mediastinal shadow is characteristic of an hour-glass tumor.

4. The mass may pulsate. This is best observed fluoroscopically or by the roentgenokymograph and if present together with a positive blood test for syphilis, an aneurysm is the most likely diagnosis.

5. The effect of x-ray treatment on the size of the mass may help distinguish between different types of lymph node involvement and may also locate the enlargement in the middle rather than the anterior mediastinum, a distinction not always easy. Lymphoblastomas are sensitive to x-ray. Leukosarcomas in children regress after roentgen therapy then later emerge with a full-blown leukemia. Benign tumors are not usually radiosensitive.

Bronchography will help in the detection of primary lung neoplasms with mediastinal metastasis and will indicate the site and degree of bronchial compression from mediastinal growths. Partial artificial pneumothorax may help reveal the exact position of the mass, its fixation, density and regularity, especially if studied fluoroscopically. Thoracentesis helps rule out encapsulated empyemas particularly interlobar types. This is especially true now since the use of penicillin locally has become popular. A localized empyema may be sterilized and converted into an inflammatory cyst.

#### CASE REPORTS

CASE 1. D. A., a fifteen year old white boy was admitted to the Indianapolis City Hospital on October 7, 1945, complaining of persistent cough, pain in the chest and loss of weight. His present illness began three months before his admission with a continual unproductive



FIG. 2. Case 11. Mediastinal tumor. M. C., four years of age. Preoperative x-rays of chest showing mediastinal tumor.

cough which persisted throughout the night. He also noticed that the slightest exertion led to exhaustion and severe dyspnea. During this period he had lost 20 pounds in weight. His discomfort was continuous and of a dull aching character which radiated down the left arm and hand. The pain and cough were aggravated upon reclining and was relieved when in the upright position. Therefore, the boy had extremely restless nights. The patient stated that he had no appetite and that his cough caused him to vomit the little food he had eaten. He had never coughed up hair. However, there had been some hemoptysis.

One week before admission to the hospital his family physician had sent him to Sunnyside Tuberculosis Sanitarium where the diagnosis of mediastinal tumor was made.

His family history was irrelevant but his past history was significant. When five years of age he was admitted to the Indianapolis City Hospital because of asthma. At this time x-ray examination of the chest showed bronchial exaggeration and some increased density throughout the middle zone of the left lung.

The significant physical findings were an increase in size of the left chest with diminished expansion and enlargement of the superficial veins. There were also flatness on percussion so that the heart could not be outlined, distant normal heart sounds with regular rate and rhythm, absent breath sounds and imperceptible vocal and tactile fremitus.

X-ray examination as interpreted by Dr.

A. A. Sullenger, was described as follows: Examination of the chest by fluoroscopy and films taken in the anteroposterior and left lateral projection demonstrated a sharply demarcated tumor apparently arising from the mediastinum and occupying most of the left thoracic cavity. The mass appeared to extend anteriorly leaving a small amount of aerated lung in the apex posteriorly and a small segment of normal lung in the left cardiophrenic angle. The cardiac and mediastinal shadows were shifted markedly to the right. The esophagus was free of any extrinsic pressure but was moved slightly to the right. The tumor appeared to be one single mass. The right lung field was clear.

Laboratory studies showed 14.6 Gm. of hemoglobin; 4,680,000 erythrocytes; 13,650 leukocytes, with 16 per cent lymphocytes, 4 per cent monocytes, 66 per cent neutrophils, 2 per cent basophiles, 2 per cent metamyelocytes and 10 per cent bands. The Kline and Kahn tests were negative. The urine was normal.

Although the tumor appeared to be in the anterior mediastinum there was no conclusive evidence that the growth was a teratoma or a dermoid, either by the history of coughing up hair or by x-ray shadows of teeth or bone. There was still the possibility of lymphoblastic disease. Accordingly x-ray treatment was started on November 1, 1945, and was continued for ten days. X-ray examination on November 20, 1945, showed no demonstrable change in the size of the mass. The patient



was prepared with sulfadiazine and penicillin for five days prior to surgery and on November 26, 1945, operation was performed under ether anesthesia.

The anesthetic was administered through an intratracheal tube. An incision was made along the course of the fifth rib extending from the posterior axillary line down to the edge of the sternum. The fifth rib was removed subperiosteally and the parietal pleura was opened through the bed of the rib. A large, encapsulated, firm, slightly nodular, tumor was encountered in the anterior mediastinum which measured approximately 23 cm. in diameter. Adhesions between its capsule and pericardium, hilus of the lung and diaphragm were divided by sharp dissection until the growth was entirely free except for its attachment posteriorly and medially. Here two large blood vessels were encountered which were branches of the superior bronchial artery and vein. They were clamped, divided and tied with No. 0 chromic catgut and the growth removed *en masse*. The lung which had been compressed posteriorly and superiorly by the tumor mass was inflated by positive pressure. Topical thrombin was applied locally to oozing surfaces. Then 50,000 units of penicillin in 5 cc. of physiological saline were instilled into the pleural cavity. The pleura and intercostal muscles were approximated with everting horizontal mattress stitches of No. 0 chromic catgut and reinforced with a continuous suture of the same material. The latissimus dorsi and serratus anterior muscles were overlapped, and the skin was closed with interrupted mattress on edge silk sutures.

Dr. William B. Dublin, pathologist, described the excised growth as follows: The specimen measured  $20\frac{3}{4}$  by  $20\frac{1}{2}$  by 9 cm. The outer surface was rough in places where dissection was necessary, otherwise smooth indicating the presence of a capsule. There were surface lobules measuring up to 10 cm. in their greatest diameter which were easily separated in places. The color varied from gray through purple to pink. On cross section the tumor was found to be solid in general, although having innumerable minute cystic spaces, most of which were filled with mucin. Trabeculae consisting of cartilage and bone were scattered throughout the mass. On pressure, a yellowish mucoid substance was seen. One portion of the surface appeared to be covered by a relatively



FIG. 3. Case 11. Postoperative film taken nine days after operation.

dense and tendinous membrane, probably immature skin, and on the surface of this there were a few fine hairs.

Microscopic examination showed a varied conglomeration of tissues from all three embryonic layers. No anaplastic cells were found, but occasional purulent areas were seen. The following structures and tissues could be identified: bronchial spaces accompanied by smooth muscle, mucous glands, cartilage, bone, connective tissue, tangled bundles of nerve fibers, encapsulated ganglion cells, hypertrophied astrocytes, some squamous epithelium, intestinal mucosa and one section of premature skin with hair.

Diagnosis: Teratoma.

The boy recovered without complications and left the hospital on December 5, 1945, in good condition. He was seen in the out-patient clinic on February 11, 1946, and was entirely relieved of all of his symptoms.

CASE 11. M. C., a four-year old white girl was admitted to the Indianapolis City Hospital without any complaints. Her parents stated that on the day of admission she had swallowed a watch chain. Part of it she vomited and the parents thought that the rest of it was in the stomach. Routine films of the chest and abdomen were made. A few lengths of the chain were found to be in the small intestine. These were subsequently passed per rectum.

The chest film, however, showed a spherical, well defined density measuring about 6 cm. in diameter arising apparently from the left anterior mediastinum. It was homogeneous and showed no evidence of teeth or calcareous deposits. The heart and lung shadows were normal. X-ray interpretation was dermoid cyst.



The child was in perfect health and had absolutely no symptoms of any kind. In an effort to rule out lymphoma, x-ray therapy was started and continued for two weeks. A check-up film made after completion of the therapy showed no change in the size of the mediastinal tumor. On September 16, 1946, an antero-lateral thoracotomy was done through the bed of the third left rib. A cystic spherical tumor was found measuring approximately 8 by 10 cm. It was attached to the hilus of the left lung and extended into the anterior mediastinum. Its attachment was very vascular. A fairly large artery and vein which were branches of the superior bronchial vessels were tied. Through-out a distance of approximately  $1\frac{1}{2}$  cm. the tumor was densely adherent to the pulmonary artery. This was dissected off with great caution but a small injury to the vessel required two lateral sutures. The tumor was completely removed and the mediastinal pleura was not closed. The pleural cavity was irrigated with physiological saline solution. One hundred thousand units of penicillin were left in the pleural cavity and the chest was closed without drainage.

The postoperative course was without com-

plication. Thirty thousand units of penicillin were given intramuscularly every three hours for four days. Thoracentesis was done on the third postoperative day but no air or fluid was obtained. The chest film on the eighth postoperative day showed no abnormalities. The child was allowed to go home on the ninth postoperative day.

Microscopic section of the growth showed a teratoma containing columnar epithelium, muscle tissue, cartilage, nerve and lymphoid tissue.

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# MESENTERIC VASCULAR OCCLUSION COMPLICATING THROMBO-ANGIITIS OBLITERANS

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THE purpose of this paper is to give a brief review of mesenteric vascular occlusion, complicating Buerger's disease and to add one more case report to the relatively scant literature on this rare complication. Von Winiwarter, in 1879, used the terms "end-arteritis" and "endophlebitis" in describing the condition of a man fifty-seven years of age, who had obliterative vascular disease of the extremities, but it remained for Leo Buerger, in 1908, to describe the disease accurately, which now bears his name.

Most of the more recent articles on this subject now consider that Buerger's disease is not limited to the vessels of the extremities, but is a generalized vascular disease, occurring in both veins and arteries and often manifest in the cerebral, coronary, pulmonary and mesenteric vessels. Fatherree and Hines state that the conception that thrombo-angiitis obliterans is a generalized vascular disease seems to be gaining ground. The frequency with which extraperipheral vascular lesions occur in individuals with thrombo-angiitis obliterans is strongly in favor of this being a generalized vascular disturbance; however, the lesion considered characteristic of thrombo-angiitis obliterans from an anatomic standpoint has rarely been found in the visceral arteries of persons with the disease, and never, to our knowledge, with an associated degenerative lesion of the arteries. They state that either the more centrally located arteries developed a tendency to arteriosclerotic lesions even though the arteries of the extremities show but little sclerosis or else as an alternative explanation that the same etiologic factor is operating but that the pathologic nature of the vascular lesion varies accord-

ing to the location in the body of the involved artery.

Meyer also describes a so-called abdominal claudication and states that the condition is entirely medical. Occlusions of small branches of the mesenteric vessels are relatively frequent. They cause symptoms of acute abdominal pain and partial obstruction, which clear up in a short time. Such a history is not infrequently obtained in old arteriosclerotic individuals. When gangrene, however, supervenes, the condition becomes surgical and the mortality is 100 per cent if left alone.

Connors, Averbuck and Silbert have all called attention to the fact that mesenteric occlusion may be due to the same type of disturbance that we find in thrombo-angiitis obliterans.

*Incidence.* Hausner, of the Mayo Clinic, reviewed the literature in 1940 and was able to find reports of only seven cases of thrombo-angiitis obliterans in which the abdominal vessels were involved. Jaeger reports five cases of thrombotic occlusion of intra-abdominal vessels accompanying Buerger's disease. These vessels were the superior and inferior mesenterics, renal, spermatic and the suprarenal arteries of the abdominal aorta. Dunphy and Whitfield, reviewing thirty cases of mesenteric vascular occlusion, report one case as being due to thrombo-angiitis obliterans. Cohen and Barron reviewed the literature on the abdominal manifestations of thrombo-angiitis obliterans in 1936 and state "investigation of the literature thus discloses only fifteen cases, suggesting involvement by thrombo-angiitis obliterans of blood vessels to the alimentary tract, a remarkably small group of these, only four, are proved, two others doubtfully

proved and the remainder presumptive. There are doubtless encountered clinically hundreds of cases of thrombo-angiitis obliterans of the extremities, in which temporary, fleeting, abdominal upsets occur—probably due to either acute thrombo-angiitis of the vessels or spasm or both.” Averbuck and Silbert reported two cases in which the celiac axis was involved, three cases in which mesenteric vessels were involved and three in which the abdominal aorta was involved in a thrombotic process. Aekman, Norpoth and Buerger also have reported instances of mesenteric vascular occlusion accompanying Buerger’s disease. Sneierson also reports one case of mesenteric thrombosis complicating Buerger’s disease. In his case at autopsy, the mesenteric veins were found to be abnormally dilated with blood clot and the vessels in general showed little pathological disturbance in the area of bowel necrosis. The wall of one medium sized vessel showed marked infiltration with polymorphonuclears.

**Diagnosis.** The two most constant findings of mesenteric thrombosis are abdominal pain and high leukocyte count. Dunphy and Whitfield state that the particular features to be noted are:

1. Regardless of the duration of the attack, the clinical picture has not been typical of the common surgical emergencies. The localized tenderness of appendicitis, the rigidity of perforated ulcer and the visible peristalsis and early distention of mechanical intestinal obstruction are not present. Usually one is able to make no definite diagnosis. However, the patients always appear ill from an abdominal lesion which simulates, but is not typical of, obstruction.

2. The character of the pain is quite out of proportion to the clinical findings and persists after ordinary measures have been instituted for its relief.

3. The only constant physical finding is deep abdominal tenderness, more or less generalized, with rebound tenderness referred to the point of pressure. In the later stages, the signs of generalized peritonitis

develop, but these should not be considered essential in the early diagnosis.

4. The leukocyte count and pulse rate are almost invariably elevated disproportionately to the temperature and other signs. Finally, it is evident that there is a gastrointestinal disturbance, but the manifestations of this are not constant. Difficulty in moving the bowels without complete obstruction, or less commonly, with bouts of diarrhea, is seen in nearly all cases. Vomiting is variable. Bloody diarrhea should not be expected, but when found, it is a valuable contributory sign. Rapidly progressing shock is uncommon and in our experience is more frequently seen in extensive venous occlusion than in arterial occlusion.

**Operation.** The essential feature at operation is to remove all of the affected bowel and mesentery with enough viable tissue to prevent recurrence or progress of the disorder. Meyer states that recovery has taken place after almost complete removal of the small intestines. Wulsten reports a case of recovery after removal of 360 cm. of small bowel and Sjoval reports a successful resection of 450 cm.

#### CASE REPORT

Mr. T. G., age thirty-three, was admitted to the Misericordia Hospital on the morning of March 5, 1946. His chief complaint was of upper abdominal pain, distention and vomiting.

The patient claimed that he was well until February 28, 1946, and at this time he was taken with pain in the epigastrium, radiating to both upper quadrants and through to the back. He had vomited off and on at varying intervals since the onset of the attack and had had but one bowel movement and that a loose stool on March 1, 1946. Since the onset of pain, he had been eructating considerable gas and passing relatively normal amounts of flatus.

Mr. G. stated that in 1938, he had suffered with a similar episode of pain which had lasted for four days and he had then secured relief and has had no symptoms referable to his abdomen since that time. For the past eight months he had been under treatment for Buerger’s disease; sympathetic paravertebral

block had been done in another hospital five months previously and during the past month, he had been receiving intravenous injections. He denied any previous operations. There was no familial history of Buerger's disease.

A systemic review was essentially negative and there were no symptoms referable to the cardiorespiratory, gastrointestinal or genitourinary systems.

Physical examination revealed the patient to be a young, well nourished male, lying in bed with his hands clasped over the upper abdomen. His temperature was 99°F., pulse rate 80, respirations 20. His head was essentially normal. His pupils were round, equal and reacted sluggishly to light. The conjunctiva was pale and showed a slight amount of icterus. The mucosa of the mouth was normal and the tongue was coated. No adenopathies were present in the neck. The thyroid was not enlarged and the trachea was in the midline. The lungs were normal to inspection, palpation, percussion and auscultation. The heart was not enlarged clinically; tones were good and there were no murmurs.

The abdomen was distended. There was marked tenderness in the upper left quadrant and there appeared to be an irregular mass in this area. Pigmentation of the type frequently seen in peripheral vascular disease was present over both ankles. The pulsations were weaker in the right dorsalis pedis than in the left. There was a small ulcer present above the external malleolus of the left ankle.

Laboratory reports on admission were as follows: Leukocyte count, 15,000.

#### Urinalysis:

Date 3/5; Color Amber; Sed. Clear; React. Acid; Sp. Gr. 1.027; Album. Trace; Sugar Plus 3; Acetone Trace; Epith. Occas.

Diac., Red blood cells, white blood cells, crystals, casts—negative.

#### Blood Chemistry:

Sugar, ven.....	140
Icterus index.....	22
Amylase.....	360

Chest examination in the upright posture showed the cardiothoracic ratio normal with no evidence of disease in the lungs or pleura. The diaphragm was smooth and regular on both sides and there was no free air beneath it. A film of the abdomen showed no enlargement of the liver. The kidneys were normal in size and

position. There was no evidence of urinary calculus. The lumbosacral spine and pelvis showed nothing abnormal. There was only a small amount and no unusual distribution of gas in the intestinal tract.

Injection of the colon with the barium enema showed no evidence of tumor or any other obstructing lesion. There was what appeared to be a slight smooth pressure effect on the inferior margin of the distal one-half of the transverse colon and possibly also of the descending colon.

A tentative diagnosis of mesenteric vascular occlusion was made and the patient was removed to the operating room.

Under continuous intraspinal anesthesia, the abdomen was opened by an upper left paramedian incision and there was considerable excess of serosanguineous fluid in the peritoneal cavity. Approximately 1½ feet of the proximal ileum, close to the jejunal junction was found to be gangrenous and there was evidence of occlusion in the mesenteric vessels to this portion of the bowel. The bowel was delivered outside of the abdominal cavity and the gangrenous portion was excised through the healthy bowel down to the root of the mesentery. The proximal and distal ends were closed and lateral anastomosis was done; the abdomen was closed in layers without drainage.

The surgical pathologic report was mesenteric thrombosis.

Gross Description: Received in moist gauze was a specimen of a portion of small bowel measuring 41 cm. in length with a portion of attached mesentery. It is reddish purple and tense. In the center there are areas of brownish black mottling. In the center the depth of the excised mesentery is 3 cm. At either end the mucosa is edematous and purplish and as one nears the center it is necrotic and covered with coagulated blood. The mesentery is 1.8 cm. in thickness and hemorrhagic. The terminal blood vessels can be identified. The lumen is filled with both coagulated blood and dark red serum.

Microscopic Examination: Sections taken from either end reveal a mucosa which is still partially viable but which is heavily infiltrated with erythrocytes and inflammatory cells. The subjacent tissue is extremely edematous and there is marked hyperemia of all of the capillary network and dense polymorphonuclear infiltration. The area from the center

shows almost complete necrosis and the mesentery is infiltrated with extravasated erythrocytes, polymorphonuclear leukocytes and fibrin. What appears to be a large vein contains a thrombus. The accompanying artery, which is well preserved, shows no evidence of thrombus formation or inflammatory reaction in its wall.

Diagnosis: Gangrene of ileum, apparently caused by thrombosis of branch of portal vein.

Following operation the patient was placed flat in bed. He was given nothing orally and a Miller Abbott tube was inserted and continuous Wangenstein suction was maintained for the first three postoperative days. One-sixth gr. morphine sulfate was given at four-hour intervals and penicillin, 30,000 units was given intramuscularly every four hours. Nutrition was maintained by intravenous plasma and glucose and the patient was heparinized, after the first twenty-four hours for the following seven days, an attempt being made to keep his coagulation time at fifteen minutes. On the fourth postoperative day, a liquid diet was permitted and the Miller Abbott tube was clamped for one hour after each feeding. On the fifth postoperative day, the tube was kept clamped and a full liquid diet, minus milk, was permitted. Prostigmine, 1:4,000 solution, one ampule every four hours for six doses, was begun on the fifth day after operation. On the seventh postoperative day, the patient was permitted modified soft diet, full soft diet on the eleventh and house diet on the twentieth day after operation.

The leukocyte count gradually returned to normal over the first sixteen postoperative days, although the sedimentation rate remained elevated. His blood urea nitrogen never exceeded 19 and the total serum proteins and A/G ratio approximated the normal. The temperature remained elevated during the first week, the temperature ranging from 99.3°F. to 101.2°F. and the pulse rate between 84 and 136. During the second postoperative week, while his temperature and pulse rate never reached the baseline, they were never exceptionally high. On the fourteenth postoperative day, following a blood transfusion, the temperature rose to 102°F. and the pulse rate to 110. It was believed at the time that this was probably a transfusion reaction, but when they remained elevated over a period of three days, x-ray of the chest was done, in spite of the fact that

there were no pulmonary symptoms. This examination revealed a homogenous density in the lowermost portion of the left lung area, due either to partial consolidation, atelectasis or pleurisy, associated with a small amount of fluid in the left base. On the eighteenth postoperative day, the temperature reached the baseline while the pulse rate became stabilized at 88. There was one slight elevation in temperature on the twentieth day after operation, up to 100°F. This fell by lysis and remained normal during the remainder of the patient's hospital confinement.

On the twenty-fourth postoperative day, the patient was given barium orally and the small bowel pattern studied. The x-ray findings revealed that the stomach was normal in size and position. Its motility and peristalsis were normal. The body of the stomach and duodenal bulb showed no pathological deformity. The entire duodenum and the proximal jejunum were well outlined with the barium and there was definite dilatation in the proximal portion of the jejunum at the site of the anastomosis. However, a considerable amount of barium passed through this area during the first few minutes after the ingestion of the meal. The one-hour film showed the head of the column as far as the distal ileum. Here again very slight dilatation and stasis in the proximal loop of jejunum was seen. There remained only a very small amount of barium in the stomach, indicating increased gastric motility. The three-hour film showed the stomach completely empty and the head of the column already in the region of the splenic flexure. There was retention of only a small amount of barium proximal to the anastomosis. The findings indicated only a slight delay but no obstruction in the region from which a large section of ileum was resected. This slight delay may have been entirely due to edema in the operative site.

The patient was discharged on the twenty-fifth postoperative day, having entirely recovered from the operation.

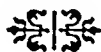
#### CONCLUSIONS

This paper presents a report of a case of mesenteric vascular occlusion, complicating Buerger's disease, in which resection was done and the patient recovered. In spite of the fact that the vessels in the

resected portion of bowel did not show microscopically the ordinary vascular lesions seen in thrombo-angiitis obliterans, yet in view of the present literature on this subject, we must consider the mesenteric vascular occlusion as part of the general picture of Buerger's disease. The history also leads one to wonder whether the attack of abdominal pain suffered in 1938, and which he describes as being similar to the pain at this time, may not have been the intermittent claudication so aptly described by Meyer and whether, in this case, the abdominal symptoms did not precede the peripheral vascular symptoms and signs.

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# INFECTED BURNS

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**E**XTENSIVE body burns present numerous surgical problems because such lesions, aside from embodying the immediate difficulties inherent in severe burns, develop other complications which are due to destruction of tissue and infection. Sequelae of the infection are necrosis and loss of skin, contractures, hemorrhage, anemia, hypoproteinemia and marked systemic reaction.

Hemorrhage subsequent to burns happens infrequently, occurs in only approximately 2 per cent of cases and is more prevalent in badly infected burns, particularly when the slough is dislodged.<sup>1</sup> This is one source of anemia. Most of the anemia in burns, however, results from infection. Hypoproteinemia occurring late in a burn is due, in part, to the loss of small amounts of nitrogen in the urine but more to the loss of larger amounts of nitrogenous materials in the exudate. This hypoproteinemia differs from that which occurs immediately following a burn both in its etiology and in its response to therapy. The syndrome of persistent fever, septic in kind, with frequent chills, elevation of pulse, evident debility and increasing prostration results from the absorption of septic bacterial products. A vicious cycle is thereby established because the anemia and the hypoproteinemia are aggravated by the infection, which in turn becomes more recalcitrant to treatment as the general condition of the patient grows worse. The case report which follows is representative of many late complications of severe burns.

## CASE REPORT

A white male, aged twenty-eight, 5 feet 8½ inches tall, weight 145 pounds, sustained a thermal burn March 13, 1943, while cooking

over a gasoline stove which exploded. When he saw his clothes afire, he became excited and ran from the site of the accident. Fortunately, he was tackled by a bystander who extinguished the blaze by rolling him over the hard surface of the desert. By then the lower portion of his fatigues, from the tops of his shoes to his hips, had been destroyed. The initial treatment consisted of a débridement in part, the application of sulfonamide ointment dressing and the administration of fluids parenterally.

The ninth day following the injury he was transferred to a General Hospital. On admission he was toxic and acutely ill (temperature 102°F., pulse 124 and respiration 26). The wound emitted a putrefactive odor characteristic of decaying flesh and he was dehydrated and edematous. Blood chemistry and laboratory findings revealed marked hypoproteinemia (plasma proteins 5.2 Gm. per cent), anemia (hemoglobin 70 per cent, red blood cells 3,500,000) and hemoconcentration (hemotocrit 55). The immediate therapy consisted of replacing the protein deficit and correcting the dehydration. As the hemoconcentration was reduced the full extent of the hypoproteinemia became evident, manifesting itself by more extensive edema and a further reduction in the plasma proteins to 4.7 Gm. per cent. So marked was the protein drain that on the third day following admission to the General Hospital, which was twelve days after the injury, 4 units\* of plasma were required to restore the plasma protein level to normal. The patient received 6 more units of plasma in the next three days. A diuresis followed, marked by an increase in the daily urinary output from 500 cc. to 3,000 cc. Three days later when the output had returned to normal the edema disappeared. From then until the infection was under control, fluid balance was a constant problem as frequent infusions of blood and plasma were required to replace the continuous protein loss and correct the anemia. (Fig. 1.)

The burned area, estimated at approximately 45 per cent of the total body surface, was made

\* A unit of plasma is 250 cc. of dessicated plasma.



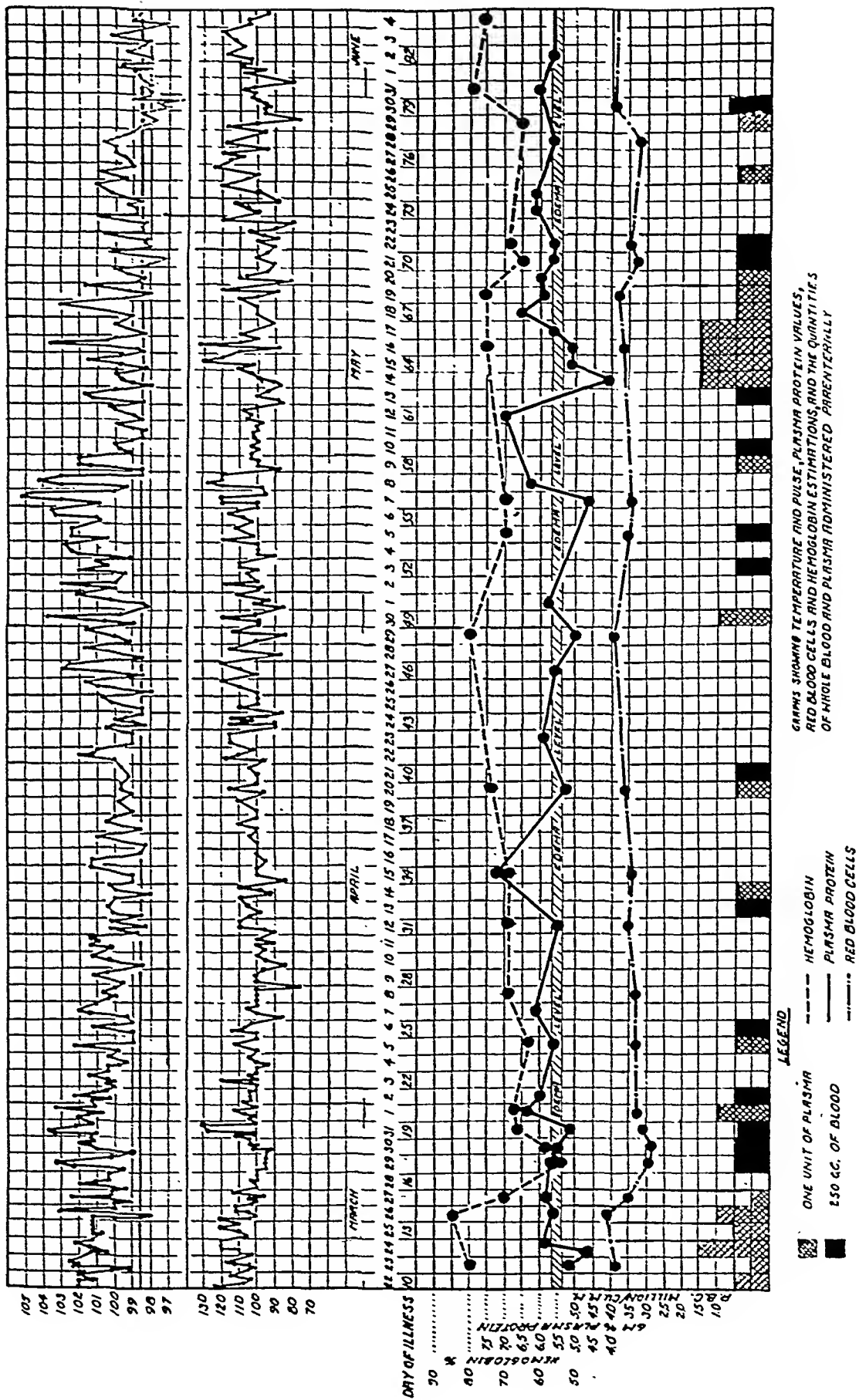


FIG. 1.



up of 10 per cent second degree and 35 per cent third degree burns. Both upper and lower extremities, the buttocks and the tip of the penis were involved. The burns on the upper extremities, which surrounded the limbs from the wrists to the mid-portion of the arms, were not deep and healed without complications even though moderately infected. The burns on the lower extremities, with the exception of small areas on the anterior surface of either thigh where the involvement was superficial, were third degree. (Fig. 2.) They extended from the malleoli to the crest of the ilia posteriorly and anteriorly to the upper-third of the thigh. The skin on the legs had been transformed into a parchment-like encasement in which the superficial veins were thrombosed and prominently outlined. The skin on the thighs was grayish-brown in color, devitalized and had a pebbled appearance where sections were distended with small collections of pus. In either popliteal space there was a sizeable pocket of pus. While the hair follicles and sweat glands had been completely destroyed throughout this area, the involvement did not extend beyond the subcuticular tissues and into the fascia or muscles.

The necrotic skin was removed from all that portion of the lower extremities which was deeply burned. This was done in six different stages, under morphine-scopolamine analgesia, starting on the eleventh day following the injury and being completed twelve days later. Sections of devitalized skin with collections of pus beneath them and portions obviously devitalized because of poor attachment to the underlying tissue were removed first. Other areas were excised as they became partly detached. The advantages of this method over that of a complete denudement in one operation under a general anesthesia will be discussed later.

During the course of the débridement, the wound was dressed with sulfanilamide powder and vaseline gauze. The patient was also receiving sulfathiazole by mouth. The drug was readily absorbed from the granulating area, producing a rapid, and perhaps even dangerous but transient, rise in the blood sulfanilamide level. The sulfonamides had to be discontinued because of leukopenia and hematuria; these conditions subsided when the drug was withdrawn. The streptococci were controlled by this therapy as they were no longer cultured

from the exudate. The elimination of these organisms, however, had no apparent beneficial effect on the patient's general condition or that of the wound. Sulfonamide therapy was followed by daily immersion baths at a temperature of 100°F., for a half hour, after which the wound was dressed with 33 per cent codliver oil in lanolin. Azochloraminide in triacetin was substituted for the ointment on occasions when an overgrowth of pyocyanus bacilli was present. Every effort was directed toward the preparation of the granulating area for grafting as soon as possible, and on the forty-first day following injury skin grafting was started.

Small, full thickness, pinch grafts were used, 100 to 150 islands being applied at one time. The popliteal spaces were grafted first and then the contiguous areas. Since immersion baths had to be discontinued at this time, the wound was treated solely with topical applications. Codliver oil ointment, although of definite value in stimulating epithelization in a superficially burned area, had very little if any bacteriostatic action. Within twenty days from the time the grafting was started, the infection on the granulating area became so pronounced that plastic work had to be temporarily discontinued. Drainage from the wound which was profuse showed staphylococci, the predominant organism on culture. The general condition of the patient was becoming worse, a secondary anemia persisted and the plasma proteins remained just above the edema level, even though large and frequent infusions of blood and plasma had been given. The patient's condition was regressing, he was showing the effects of long continued infection and it appeared as though he might succumb to septicemia. Fortunately, insofar as could be ascertained from blood-chemical studies, urine examinations and functional tests, there was no evidence of liver or kidney damage.

A concerted effort was then made to replace the protein deficit and maintain the proteins well within the normal limits, instead of just above the edema level as had previously been attempted. The anemia was combated simultaneously. In a period of two weeks, which was fifty-eight to seventy-two days following the injury, the patient received 6,000 cc. of plasma (24 units) and 2,000 cc. of citrated blood. He suffered one moderately severe, delayed reaction from a blood transfusion but with no ill effects. During the same period succinyl sulfa-

thiazole was applied locally, 4 Gm. being used with each dressing. A definite improvement in the general condition of the patient and in the wound soon followed. Drainage from the granulating area became minimal and within the next ten days, which constituted an interim of thirty-seven days since the last plastic work had been done, the skin grafting was resumed. Small pinch grafts were used, because of ease of application and greater possibility of survival on an area showing so much infection. Split thickness grafts were preferred but could not be employed for technical reasons. Inasmuch as it was necessary to get the area covered as soon as possible, the most expedient method was used. The entire area was covered in a series of twelve operations. Small ulcers from which microaerophilic streptococci were cultured formed in several of the grafted areas. These lesions responded to zinc peroxide. When transferred from the hospital to the Zone of Interior, the patient was ambulatory and had good motion of his extremities. Later communications revealed that further plastic work was done; he has since been returned to active duty.

#### COMMENTS

The treatment of deep burns with infection is sub-divided into the problems of denudement, control of infection, maintenance of proper fluid balance, correction of anemia and hypoproteinemia, the prevention of contractures and skin grafting.

Devitalized skin and infected eschars are removed as soon as practicable in order that absorption from infected and necrotic tissue be kept at a minimum. This has been done in one operation under a general anesthetic, but it is ill advised since the process of denuding large areas is attended with dangers from both the anesthetic and the operation. Furthermore, sections of viable skin are frequently sacrificed if the eschar is excised prematurely. This can be proved by making histopathological sections of the tissue removed. Even though absorption from necrotic tissues may be lessened by removing the eschar in one operation, that advantage in no way compensates for the added risk to the patient and the sacrifice of viable skin. An effective



FIG. 2. A and B, burn on the posterior surface of the lower extremities before and after removal of eschar; C and D, burn on anterior surface of lower extremities with eschar partially and completely removed.

way of caring for such areas is to drain all collections of pus as they form and remove the devitalized skin gradually, waiting until its attachment to the underlying tissue loosens before excision.

The amount of tissue destruction produced by a burn is difficult to estimate at the time of injury. Infection of the part further increases the amount of tissue loss; however, the depth to which a burn will penetrate and destroy tissue is generally dependent upon the causative agent and its length of contact. Burns produced by boiling water usually affect only the outer layers of skin; whereas those caused by steam under pressure, other liquids and fats at high temperatures, heated and molten metal and explosions may involve both skin and subcuticular tissues. Chemicals, if

concentrated and not immediately neutralized, will cause marked erosion of tissues. Burns incurred when clothing becomes ignited tend to be deep, particularly if the fire is not immediately extinguished. Electrical burns are often deep and insidious.

Burns become infected from contamination of the skin and clothing of the patient or because of poor surgical technic during the initial treatment or subsequent dressings. Burns treated immediately following injury by gentle cleansing with a minimum of débridement, sterile vaseline gauze and pressure dressings and plasma and blood replacement will harbor fewer organisms than those, which because of extenuating circumstances, cannot be as well attended. Although burned surfaces cannot be rendered and kept sterile, proper early treatment will so reduce the number of pathogens in first and second degree burns that healing will ensue without complications. Deep burns are more prone to become infected because of extensive necrosis of the tissue. Invasive infection causes further destruction of the epithelial cells in the deeper layers of skin.

Meleney<sup>2</sup> states that cultures from burns commonly show mixed infections. This has been confirmed, not only in the case herein presented, but in other infected burns. Organisms usually cultured from the wound are staphylococci, streptococci, *Bacilli subtilis*, coli, proteus and pyocyaneus and anaerobic and micro-aerophilic organisms. Tetanus and gas bacilli infections are to be prevented in all burns. The source of the invading organisms is evident. Staphylococci are found on the skin and live and grow in sebaceous glands, sweat ducts and hair follicles; streptococci are present in the nose and throat; *Bacilli coli*, proteus and pyocyaneus are common inhabitants of the gastrointestinal tract; diphtheroids and the *Bacillus subtilis* are frequently found on the skin, while the source of the micro-aerophilic organisms is uncertain.

Control of the invading organisms is of paramount importance, both because of their devastating action on the wound and

also because of their systemic effects. Of primary import is the preparation of the granulating surface for grafting as soon as possible by reducing its bacterial flora. Topical applications and hot compresses may be of some value in helping to clear the local infection, but since the action of the invading organisms frequently extends beyond the local lesion, other therapeutic measures must be used. Some organisms are readily eradicated because they respond to specific drugs, whereas others are more recalcitrant to treatment. Streptococci and other sulfonamide sensitive organisms cause less concern in burns than organisms resistant to sulfa drugs since the former group is controlled by sulfonamides when given by mouth. Staphylococci are frequent and serious invaders of burns; those organisms are more difficult to control but generally respond to penicillin administered systemically and succinyl sulfathiazole applied locally.

Although chemotherapeutic agents alone or in combination are definite adjuvants to the treatment of infection, the establishment and maintenance of proper nutrition is most essential. In a burn of this extent, in which 45 per cent of the body was involved, the protein drain generally cannot be compensated for by diet alone, since the patient is usually unable either to ingest or to tolerate the large quantity of proteins needed. Powdered milk, which contains 27 Gm. of protein per 100 Gm., is an effective way of supplying proteins orally. Co Tui et al.<sup>3</sup> kept a patient with a burn involving 50 per cent of the body area in a good state of nutrition with high caloric and nitrogen feedings in the form of dextrimaltose and amigen. They maintain that a mathematical relationship apparently exists between the extent of the burned surface and the amount of nitrogen required to maintain nutrition. The protein drain increases as the infection becomes more marked, as evidenced by the nitrogen loss in the urine and the profuse amount of exudate. The patient herein reported was given blood and plasma as nutritional

adjuvants (Fig. 1), receiving 53 units of plasma (13,250 cc.) and fourteen transfusions (7,000 cc. of blood) while in a General Hospital. This replacement therapy is effectual, although expensive, and not the most efficient way of supplying proteins, as 100 cc. of plasma contains 7 Gm. protein and 100 cc. of blood, 18 Gm. protein. Any anemia should be corrected along with the hypoproteinemia, as anemia supposedly retards the regeneration of plasma proteins. Whipple<sup>4</sup> believes this is due to a priority which the regeneration of hemoglobin appears to have over the available protein.

#### SUMMARY

1. Complications occurring in severe burns which become infected have been discussed.

2. Salient features of the treatment are: (1) gradual removal of the eschar to avoid unnecessary skin loss and added risk to the patient, (2) control of infection and preparation of the wound for grafting as soon as possible, (3) skin grafting and the preven-

tion of contractures and (4) correction of anemia and maintenance of proper nutrition.

3. The necessity of establishing and maintaining adequate nutrition is again emphasized. If the protein loss cannot be compensated for in the diet, synthetic proteins must be given by mouth, and plasma, serum and blood parenterally as indicated. Any anemia should be corrected along with the hypoproteinemia.

4. A case, representative of a severe burn which became infected, is presented.

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# VILLONODULAR PLASMA CELL SYNOVITIS\*

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THE term "villonodular synovitis" has first been introduced by Jaffe and co-workers in 1941 to designate pig-



FIG. 1. X-ray picture of ulnar lesion.

mented lesions of tumor-like appearance which occur in joints, bursae and tendon sheaths. A brief review of his article<sup>1</sup> shall precede the report of our own case. The gross appearance of the lesion varied greatly. It was predominantly villous, nodular or represented a combination of the two. In many cases the villi or nodules were fused and the whole joint cavity obliterated by a soft tissue mass. One outstanding characteristic was pigmentation, the color of the lesion varying from reddish-brown to yellow.

Microscopically, the villous lesions showed the villi to be covered by synovial cells in one to three layers. The supporting connective tissue stroma of the villi was loosely textured and composed of polyhedral or spindle-shaped cells. Villi contained a considerable number of thin-walled vascular channels, an occasional one of which was encircled by a cuff of small lymphocyte-like cells. The outstanding histological feature was the presence of brownish pigment granules; in addition, there were hemosiderin-bearing and lipid-bearing foam cells and multinuclear giant cells. In the more complex lesions presenting a fused or matted villous appearance, the spaces between the villi were reduced to narrow clefts lined by synovial cells.

The authors state that in the past, often because of the baffling cytologic picture, many observers have overlooked the basic pathologic process and have named the lesion according to some outstanding gross or microscopic manifestation. Thus among the names applied to this condition are the following: chronic hemorrhagic villous synovitis, giant cell fibrohemangioma, fibrohemosideric sarcoma and polymorphocellular tumor of the synovium. The total number of cases of pigmented villonodular synovitis at the time Jaffe's article was published was fifty-seven including twenty

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FIG. 2. Low power view of joint contents.

Pulp of the villi consisted of closely packed polyhedral and foam cells with or without pigment. Variable numbers of multinuclear giant cells were also present. The authors emphasize the variability of the microscopic pattern, different areas being dominated by one or another cell type. Marked collagenization and hyalinization of the stroma was seen in the older lesions. The authors reject the idea that the lesions represent a tumor in the true sense of the word, or that it is the result of intra-articular hemorrhage or local lipid imbalance. They believe that it represents an inflammatory response to some as yet unknown agent.

Although Jaffe's publication presents a very exhaustive study of the subject, we feel justified to report another case of our own observation because of the relative rarity of the lesion among surgical specimens in a general hospital and certain deviations from the description of the lesion by Jaffe.

#### CASE-REPORT

The patient was a forty-five year old white male, and bus driver by occupation. In May, 1945, he stated that he struck the ulnar aspect of his left wrist against the steering wheel of a bus. He had pain in the wrist for two or three days followed by swelling which increased

slowly but steadily in size. In July, 1945, he consulted a physician who incised the swelling, telling him that it was a "ganglion." Some clear amber colored fluid was obtained. The wrist and arm were put in a cast for nine weeks. At the end of this time, the swelling was still present although the wound had healed.

In January, 1946, he consulted another doctor who sent him to the hospital. The lesion was described as a firm but not hard mass at the distal end of the left ulna, measuring  $1\frac{1}{2}$  cm. in diameter. Except for this finding, physical examination was essentially negative. Laboratory studies were not contributory. X-rays of the wrist revealed a circumscribed area of decreased density at the distal end of the left ulna surrounded by a narrow zone of increased density with a fuzzy appearance. There appeared to be some involvement of the lateral side of the radius. Comparison with x-rays taken several months earlier showed some increase in the size of the lesion. At operation, February 1, 1946, the joint capsule was thickened and somewhat distended. Upon entering the joint, the synovium was found to be covered by a thick layer of soft, shaggy, grayish-white "granulation tissue." There was a small amount of gelatinous, straw-colored fluid in the joint. The distal end of the ulna was rough and irregular. The distal 3 cm. of the ulna were resected and the granulation tissue clipped away.

The pathological findings were as follows: Grossly, the contents of the ulnar-radial joint

FIG. 3.

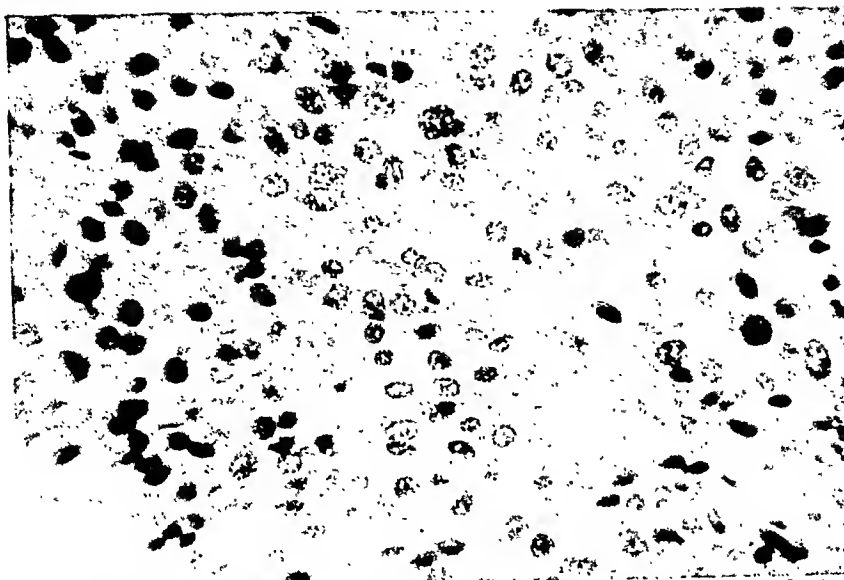


FIG. 4.

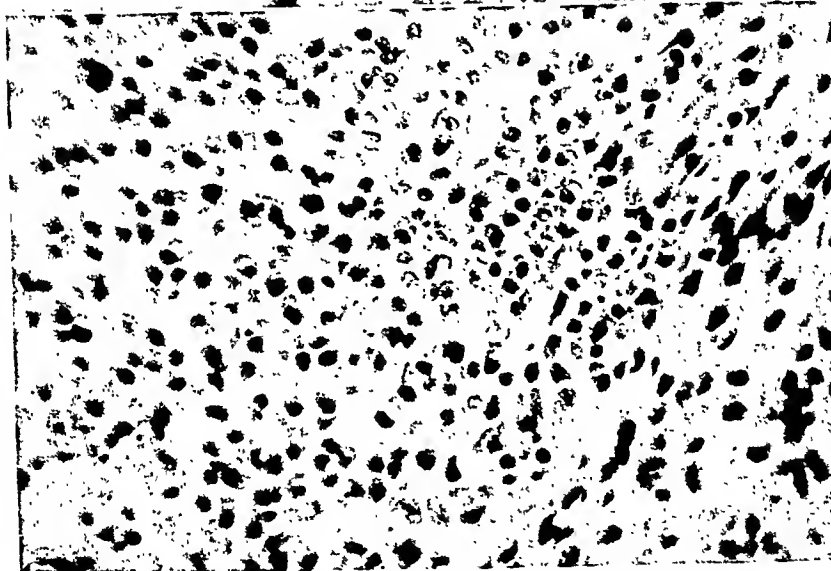


FIG. 3. High power view showing synovial villi.

FIG. 4. High power view showing extensive plasma-cell infiltration of the villi.

resembled granulation tissue and were devoid of any characteristic pigmentation. Contrary to Jaffe's statement that roentgenography is of little value in diagnosis except for confirming the soft tissue swelling, we found in the x-ray picture (Fig. 1) a definite ragged corrosion of the distal end of the ulna. The appearance of the resected distal end was in accordance with the x-ray shadow.

Microscopic sections (Figs. 2 to 4) were made from both, the bone and the joint contents. The bone sections were completely negative for any penetration of the synovial proliferative tissue. The structure of the joint contents presented villous processes separated by narrow channels and was composed of com-

pact sheets and masses of polygonal and polyhedral synovial cells of fairly uniform size and equal staining power of the nuclei. There was a considerable amount of intervening, partially hyalinized connective tissue. Multinuclear giant cells were present but these were very few in numbers. No pigment of any kind was discernible. Outstanding and partially obscuring the basic cytologic pattern was a heavy infiltration of the villi (Fig. 4) by clusters and collections of plasma cells intermingled with varying numbers of small lymphocytes. Sections were sent for confirmation to Dr. Fred Stewart at the Memorial Hospital in New York City who classified the lesion as villonodular synovitis.



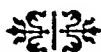
## COMMENT

The basic structure of synovial cell sheets in villous and nodular form is the finding by which our case conforms to the description in Jaffe's series. There is, however, a conspicuous absence of pigment the occurrence of which is so much stressed as a typical feature in Jaffe's cases. Even more prominent is the inflammatory plasma cell reaction. We find no mentioning of the

latter in Jaffe's report. We are inclined to believe that the post-traumatic inflammatory process was primary and set the synovial proliferation in motion. Although superficially corroding the articular surface of the bone, no deeper penetration could be found.

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IN cases of purulent arthritis of the ankle-joint there is often a sympathetic effusion into the tendon sheaths. It is possible that suppurative tenosynovitis may be confused with purulent arthritis, but as the former condition is likely to be confined to one set of the synovial tendon sheaths, the differential diagnosis is not usually difficult.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams & Wilkins Company).



# ENTERIC CYST

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**C**ONGENITAL cysts arising from the gastrointestinal tract have been referred to as enterocystoma.<sup>1,2</sup> enterogenous cysts,<sup>3</sup> giant diverticula, ileum duplex inclusion cysts, duplications of the alimentary tract<sup>4</sup> and enteric cysts.<sup>8</sup>

The following case is reported because of the rarity of the condition, the diagnostic difficulty presented and because no previous case of such a size has been reported to our knowledge.

## CASE REPORT

A nine year old colored female entered our hospital December 7, 1945, at which time she complained of a swollen abdomen. The child had a noticeable abdominal protuberance since birth. One week before admission she had an episode of vomiting green material that lasted for three days. She noted during this time that she was having pain in the epigastrium which seemed to radiate over the entire abdomen and was accompanied by increased swelling. The family history was non-contributory.

The child was comparatively well until the age of seven, at which time she complained of epigastric pain, abdominal swelling and vomiting. She was admitted to another institution on July 16, 1943. The clinical impression at that time was ascites of undetermined origin, most likely tuberculous peritonitis. The record obtained from the other hospital reported considerable relief following an abdominal paracentesis. A chemical analysis revealed the protein 4.0 Gm. per 100 cc., a negative culture and a smear for acid-fast bacilli and other microorganisms. An x-ray of the chest revealed no parenchymal involvement.

At the time she was admitted to our hospital the transfer diagnosis from her local physician was that of Banti's disease. On physical examination the patient was a well developed but emaciated colored child, not acutely ill. Her temperature was 98.6°F., the pulse was 75 and the conjunctiva was extremely pale. The positive findings of the examination were limited to the abdomen which appeared greatly dis-

tended and exhibited a fluid wave and shifting dullness. Laboratory findings other than a mild secondary anemia were uninformative.

During the present admission an abdominal paracentesis was attempted on two occasions. On one, no fluid was obtained; on the other, only 100 cc. of cloudy, straw-colored fluid was obtained which contained some fibrous shreds and had a specific gravity of 1.016. On October 11, 1945, the abdomen was opened through a low midline incision where a cystic mass, so large that it displaced all the abdominal viscera, was seen. It was adherent to the parietal peritoneum at the site of previous paracentesis and extended from the brim of the pelvis to the dome of the diaphragm. To facilitate removal the contents of the cyst, which consisted of 3,500 cc. of cloudy, straw-colored fluid, were aspirated. It now became apparent that the cyst had its origin from the antimesenteric border of the small intestine, approximately 3 feet from the ileocecal junction. The wall of the cyst blended with that of the small bowel so intimately that surgical dissection, one from the other, was impossible. The small bowel was divided proximal and distal to the cyst and the entire mass removed. Then an end-to-end anastomosis of the ileum was performed. The patient received supportive treatment postoperatively and the convalescence was uneventful. She was discharged on the thirty-eighth postoperative day completely well.

The pathological report showed the specimen to be a cyst, covered with peritoneum, measuring 30 by 23 cm. The wall was 0.5 cm. in thickness consisting mainly of fibrous tissue. On microscopic examination occasional muscle fibers were discernable. The tumor originated from the wall of the small intestine; the intestinal wall being incorporated with the wall of the cyst. *Diagnosis:* Enteric cyst.

## COMMENTS

Several theories have been advanced as mentioned by Ladd and Gross<sup>4</sup> to explain the origin of these cysts: (1) That they are due to a remnant of the omphalomesenteric

duct. While Meckel's diverticulum is the most common form of anomaly due to improper closure of this duct, any remnant of the embryological structure may remain to form such an anomaly; (2) twinning of an isolated portion of an embryo has been thought by some to be the causative factor; (3) cell rests from the primordial intestinal tube which finally obtain all of the histological elements of the wall of the intestine might account for the development of these cysts and (4) Lewis and Thyng<sup>5</sup> advanced the explanation that enteric cysts originate as fetal out-pouchings of the intestinal wall not related to Meckel's diverticulum which normally regresses, but in these cases they pinch off from the intestinal wall and give rise to a duplication. These are frequently found in the fetal alimentary tracts of man, cats, sheep, pigs and rabbits. The out-pouchings are most common in the ileum suggesting a relation of high incidence of such anomalies in the ileum.

Clinically, enteric cysts are a condition of childhood and may occur as duplications of the alimentary tract anywhere from the mouth to the anus. A series of eighteen cases reported by Ladd and Gross<sup>4</sup> vary in ages from two weeks to nine years. Beardsley<sup>1</sup> reported a case where the subject was eight years old. Sawyer<sup>8</sup> reported on two patients, one six years of age and the other eight months old. A few other cases have been reported.<sup>2,3,6,7,8</sup>

The symptoms produced by these lesions are largely symptoms due to pressure of these cysts upon adjacent viscera, thus resulting in obstruction. Patients with cysts occurring at the terminal ileum have even been operated upon for acute appendicitis. In the case reported herein the symptoms were predominately abdominal distention due to the large size of the anomaly, general emaciation from abnormal intestinal physiology and finally intestinal obstruction due to infringement of the cyst on the normal lumen of the intestine.

Consideration of the treatment depends

on the location of the cyst and its type of attachment to the alimentary tract. Narrow pedicled cysts may be readily handled by division and transfixion of the pedicle as reported by Beardsley.<sup>1</sup> A broader pedicled cyst, as reported here, presents a more difficult problem. In this case complete excision of the cyst with removal of the attached portion of the intestine was accomplished. This method of treatment has been recommended by Ladd and Gross<sup>4</sup> as the treatment of choice because the wall of the cyst and the intestinal wall blend imperceptibly into each other so that the two cannot be dissected apart. When excision is impossible because of difficulty in mobilization of cyst attachments, marsupialization of the cyst is feasible. If the condition of the patient prohibits resection and primary anastomosis, exteriorization of the cyst with formation of a spur of the attached intestine, as in the Mikulicz procedure, seems to be the most reasonable method of handling the condition.

#### SUMMARY

1. A case of intestinal anomaly which we prefer to call enteric cyst has been presented.

2. These anomalies are relatively rare, they occur usually in children, they present a definite clinical entity and can be cured with the proper surgical procedure.

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# SUCCESSFUL OPERATION FOR IMPERFORATE ANUS AND IMPERFORATE RECTUM

## THREE YEAR FOLLOW-UP REPORT

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ALTHOUGH estimates vary as to the incidence of malformations of the anus and rectum in the newborn, the consensus of opinion among proctologists whose experience has been culled during the past seventy-five years, points to an incidence of about one in every 10,000 births. Even these statistics are not entirely accurate for they refer to gross malformations; malformations of a partial nature which presented no physical symptoms in early life were not included. Many people have gone all through life without ever knowing that any rectal abnormality existed. The incidence of all types of anal and rectal abnormalities would certainly be reported as greater, if a more systematic examination of the rectum in the newborn was performed by the attending physician.

According to Rankin, Bagen and Buie, "ano-rectal anomalies can in most instances be explained on the basis of arrested or irregular development of the embryonic proctodeum and post-allantoic intestine, with or without persistence of the communication with the cloaca."

Yeomans delineates the usual situations found as follows: (1) The epiblast does not invaginate at the canal site and the anal canal is absent; (2) there is a rudimentary or developed anus partly or completely occluded by a persistent anal membrane; (3) the postallantoic undeveloped intestine does not descend and ends blindly without function; (4) the post-allantoic intestine descends but grows backward out of alignment with the proctodeum: thus intervening tissues are not absorbed and there is no function; (5) the urorectal partition of the cloaca is arrested, the rectum communicating with the bladder, urethra, vagina or perineum and the

anus is usually completely closed with restricted function; (6) the urogenital outlet is in the rectum and (7) there is a persistence of the neurenteric canal with the opening of the postanal intestine in the sacral region.

The case under consideration is that of a newborn infant who had a complete absence of the anus, sphincter, anal canal and rectum.

### CASE REPORT

A baby boy F. C., was delivered by cesarean section at Huntington Hospital, Huntington, N. Y., on March 5, 1943, at 9:40 P.M. The baby's weight was 7 pounds, 3½ ounces. Apparently no gross abnormalities were noted at the time of delivery, for the nursery called the attention of the attending physician to the fact that on cleaning and oiling the baby no meconium was seen and on closer inspection no anal opening was found. On the morning of the next day, March 6, 1943, the baby was referred to the author for examination and disposition. An external examination showed merely a dimple at the end of the raphe leading down from the scrotum, with the dimple situated higher up than the usual anal site. There was no discoloration or bulging at the perineum when the baby cried, strained or when the abdomen was pressed.

The baby was operated upon the same day at 4 P.M., without an anesthetic and with the baby placed in the lithotomy position. The dimple was incised first. There was no escape of meconium or gas nor evidence of any anal canal or external sphincter. The incision was then extended posteriorly to the tip of the coccyx. By blunt dissection, using gauze on the index finger and at times a pair of Metzenbaum scissors, the author explored along the coccyx and sacrum, also laterally and anteriorly but was unable to find any evidence of a rectum. Having reached the promontory of the

sacrum, he arrived at the pelvic floor where, by careful blunt dissection and teasing with the Metzenbaum, the sigmoid colon was exposed. The latter was shown as a blind end, distended and discolored and situated at the anterior portion of the floor about 6 cm. proximal to the outside. The author believes that he was extremely fortunate in finding this piece of bowel when one takes into consideration the extent of the anatomy concerned in the field of operation. Briefly, the distance in infants between the tuber ischii is normally 2 cm., that from the scrotum to the coccyx averages  $4\frac{1}{2}$  cm., while the distance from the normal site of the anus to the tip of the coccyx measures  $1\frac{1}{2}$  cm. These measurements give the reader an idea of what we had to contend with anatomically.

Having exposed the sigmoid colon, the attachments were then freed and by careful teasing the writer was able to bring the sigmoid down to the cut edges at the outside where the anus would be situated normally. After insufflating 30 grains of sulphathiazole powder into the perineal cavity, the bowel was anchored with several No. 0 chromic catgut sutures, followed by an incision of the colon. The result was an escape of a large amount of meconium and gas. The mucus membrane were then sewed to the cut edges of the skin with interrupted No. 0 chromic catgut sutures.

A few pertinent notes of the baby's progress during its stay at the hospital are given here at this time: On March 8th, greenish stools came through the new anal outlet; on March 18th, the incision posterior to the new anal outlet was fairly loose, due to straining at stool. The new anal outlet at the mucocutaneous junction continued to stay in place. There was a mild grip to the anal outlet when a cotton applicator was introduced. The perineal wound was healing well. The baby was discharged from the hospital in good physical condition, weighing 7 pounds, 12 ounces.

The baby was followed up in my office and below are relevant excerpts from my office records: The weight of the baby on May 7, 1943 was 13 pounds. The anal opening admitted a cotton applicator. The anal canal was to be dilated at home by the mother several times daily, using various sized urethral catheters for this purpose. On June 2nd, on stretching the new anal canal, one observed a small amount of bleeding. Stretching with the urethral

catheters was found to be succeeding. In November, the weight of the baby was 18 pounds, with fairly good control of the stool. Due to continued stretching of the anal canal, the catheters had been discarded and in their place a set of Wales bougies were used. The canal could be stretched with a No. 14 Wales.

In March, 1945, the baby's weight was 28 pounds, its height  $34\frac{1}{2}$  inches. The anal opening admitted the index finger. There was a ring of scar at the anal canal which gripped the finger moderately when one did a digital examination. The mother stated that the baby had two to three movements daily. In September of the same year, the baby averaged one to two movements daily which he controlled very well, with an occasional loss of a small amount of stool. For the past five months the mother had been inserting the bougies at three- to four-day intervals. Examination of the anal canal with the index finger at that time indicated a moderate grip. February, 1946, the weight of the baby was  $34\frac{1}{2}$  pounds, with the height  $36\frac{3}{4}$  inches. We found a well developed boy, bright, alert and in good physical condition. There was good scar control in the anal canal. Since the first of the year the mother had discontinued the use of the Wales bougies, finding them unnecessary.

#### SUMMARY

A newborn infant, born with complete absence of the anus, sphincter, anal canal and rectum, was successfully operated upon via proctoplasty eighteen hours after birth, bringing down the sigmoid colon to serve as the new anal canal and rectum. The boy is now three years old and normal in every other respect. The formation of scar in the new anal canal, together with more progressive use of the gluteus maximus muscles, has effectuated very good control of bowel movements. The author has proctoscoped the boy several times during the past year, never finding evidence of the rectal valves, or so-called folds of Houston. This, together with the appearance of the intestinal anatomy at the time of operation, is the basis for the author's conviction that it is not the rectum, but rather the sigmoid colon, which is now functioning as an anal canal and rectum.

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Correction: In our June, 1947 issue, on page 675 in Table v, the author wishes to call attention to an item under "Radical operation. . . . (2) Total nephrectomy." In the column entitled "Result," figure five should have appeared under the subdivision "Died."

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## Editorial

### INSTILLING THE WILL TO GET WELL

FOR years we have called attention to the "Humanics of Industry," insisting that consideration should be given to the needs of the injured workman himself as well as to his injury. This theme was ably presented in *The American Journal of Surgery*, February, 1942, by Robert H. Kennedy who stressed the fact that the injured man is not a sick man and must not be treated as one. We have seen instances in which disproportionate and prolonged disability has resulted from too little attention to the needs of the individual during his convalescence, even when skillful treatment has been given to the injured part. With the development of finer hospital facilities and greatly improved surgical technics we have come to the realization that these are important but not exclusive factors in the successful repair and rehabilitation of the injured. The importance of a proper emotional adjustment on the part of the workman to his injury has become increasingly apparent and enforced periods of prolonged inactivity are now recognized as being detrimental to the human machine as a whole.

Occupational therapy has come to occupy an important place in the treatment and rehabilitation of the injured workman and excellent results are obtainable by the early performance of selected tasks. Not so well recognized, however, is the danger of

allowing the patient to settle into a "therapeutic rut." We believe that "work therapy" should replace occupational therapy as soon as it can be done with safety and in most instances industry, recognizing its obligation to the injured workman, is eager to cooperate in the suitable placement of its employees. Our experience in the application of work therapy, however, prompts a word of warning. The morale of the worker is given an immediate lift when he is given the opportunity to "earn as he heals," but to be effective in shortening his period of ultimate recovery his progress from this point must be carefully regulated so that his rehabilitation is continuous and progressive. In most patients it is a mistake to refer to work therapy as "finding an easy job." It is far better to speak of placing the individual on "selected work" for a definite purpose and for a definite period of time. Complete recovery and a return to his original job is often delayed unnecessarily because the worker is permitted to regard an easy job as compensation for his injury rather than as part of a logical therapeutic regimen. The "will to get well" must be instilled. The surgeon must adapt himself to the needs and requirements of industry and the man; the man and his job.

As we review the phenomenal growth of industrial medicine and surgery in the last

two decades, we are impressed with the fact that industry is conscious of its obligation to provide competent treatment for its injured employees and a more critical attitude is taken toward the qualifications of those who would profess to be industrial surgeons. If the surgeon is going to perform industrial (traumatic) surgery, then he should understand industry. Above all he must understand the working man and his problem. Kindness and consideration for the "human machine" must be a part of the treatment. There is, however, an understandable reluctance on the part of many good surgeons to accept industrial accident cases in some parts of the country, which can be traced to an unwillingness to become embroiled in compensation proceedings. The result is that too much of this important work is being done by men whose only qualification is a willingness to assume the risk of spending hours each week in medico-legal joustings with compensation lawyers. Even in those states where industrial physicians are rated or classified on the basis of their qualifications, there is a need for setting higher standards to safeguard the injured workman from incompetent surgical treatment.

The increasing number of able surgeons who are doing excellent work in the treatment of industrial injuries is in a large measure due to the work of such great teachers as Moorehead, Murray, Marble, Magnuson, Gurd and many others who continually spread the gospel of better

care of the injured. Much credit reflects on the members of the Committee on Fractures and other Traumas of the American College of Surgeons, for their valuable contribution to the education of the general practitioner in the proper management of injuries and Kanavel, a grand person and able surgeon who left a fitting monument to his memory in his classical "Infections of the Hand."

The proper treatment of small trauma has claimed the attention of such outstanding teachers as Koch and Mason, and justly so, for the care of smashed fingers and similar injuries is an important phase of industrial surgery to which too little consideration has been given in the past. Between major and minor traumatic surgery is that field for which we have often used the term "major-minor surgery." Not so much emphasis has been placed on this phase of surgery but approximately a year ago Bancroft gave us an excellent discussion which is notable for the sound principles expressed.

In this issue of the Journal we have attempted to gather together articles of timely interest to industrial surgeons written by authors who understand their problems and have something new to offer—new ideas, new methods or new points of view. Each is a worth while contribution and we are grateful to the authors for their assistance in the preparation of this issue.

LOYAL A. SHOUDY, M.D.



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# Original Articles

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## SURVEY OF TRAUMATIC SURGERY

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IN any retrospective review of many decades the tendency is to emphasize certain features with which a writer has been personally identified. However, in order not to make the story too replete with the experiences of one individual, it will be the writer's endeavor to survey some of the outstanding gains in the field of traumatic surgery.

Probably the most satisfying element is the very definite place this branch of general surgery has attained. As with other subdivisions of surgery the subject of trauma is now accorded a realm that virtually means at least an approach to specialism. In many teaching institutions and in most hospitals the treatment of traumatic lesions is a segregated feature with the result that students, the profession and the laity are now accident and injury conscious to an extent that was unknown hitherto. The automobile age, the two world wars and the development of industrial practice are among the major factors in this established recognition.

However, the general advance in every surgical endeavor is also a feature, and the stimulus and example set by surgeons in other fields has stimulated those engaged in traumatology to greater endeavor to defeat the three horsemen of trauma—shock, hemorrhage and infection. It is recognized that traumatic surgery differs from general surgery in many essentials, notably in that there is no incubation period in trauma because the effects of external violence register instantly and the patient has no time to build up bodily defenses nor are there any preliminary symptoms. Furthermore, traumatic surgery

is essentially a salvaging project and the surgeon who treats the injured is, in reality, a repairman. The general surgeon removes and the traumatic surgeon retains the damaged parts. In trauma a minor injury often is converted into a major catastrophe because of the onset of infection or the presence of some constitutional ailment, such as cardiovascular, pulmonary or diabetic associates. In general surgery these medical factors can be evaluated properly because the time element differs and the emergency features are less immediate. Traumatic surgery is the most nearly public property of any type of surgery and usually is subject to critical review by the patient, family, friends, neighbors and various legal agencies. In fractures the x-ray films supply additional evidences, to say nothing of the facial or other scars and the notable limp as the outcome of an automobile mishap. General surgery escapes most of this scrutiny and the postoperative hernia following the laparotomy is rarely discussed except by the patient and the family, and less rarely is the gaping scar exposed to public view. Furthermore, in general surgery the removal of an appendix or a gallbladder is a hazard known to the patient, and the outcome, if unsuccessful, is not charged to the surgeon, as is the case of a fracture of the lower third of the tibia and fibula resulting in non-union or a deforming limp. In a broken bone a cabinetmaker repair is expected by the victim; in a ruptured appendix the patient accepts the outcome and places no blame upon the surgeon who performed the operation, nor does he sue for malpractice if dissatisfied.



In appraising the experiences in traumatology it may simplify the matter if we assume that 80 per cent of traumatic effects register as: (1) wounds; (2) burns; (3) joint and tendon involvement and (4) fractures and dislocations. In all of these we predicate the three major sequelae in trauma which are to be defeated, namely, disability, deformity and death.

Shock, hemorrhage and infection are the three associates, as already indicated, and it is a happy retrospective reflection that all of these are nearly subjugated. We recognize that inevitably certain injuries are fatal because of their site and severity. In another group of major importance, prompt and efficient treatment brings success. A third group is almost invariably recoverable in terms of function and form. Stated in another way, experience teaches that the outcome may be summated by saying that in one group the result is a fatality no matter what we do. In another group recovery is assured whatever we do and in the third group the end result depends on what we do.

*Shock* in the olden days was recognized by the same cardinal visible signs still prevailing but the differentiation from hemorrhage was baffling and often determined only by operation or autopsy. Likewise, the treatment was varied and very often empirical, lacking animal and laboratory verification. It is true that no universally accepted definition of shock is available but that does not detract from the truism that this destructive agency is now more easily recognized and controlled. The advent of blood, plasma and their derivatives has changed this drab picture so that many useful lives are saved. The day is not far away when a blood substitute will be available and thus this scourge will be more definitely conquered.

*Hemorrhage* is another foe that decades ago presented visible evidences to the experienced observer, but here also the clinical picture was fogged by shock as the sole or associated factor. Thanks to zealous and careful research this puzzle is also in

the process of being solved from a diagnostic standpoint, as cumulative experience has demonstrated the sovereign power of transfusions. Thus, these two elements that defeated any salvage project are no longer in the doubtful stage but actually are en route to defeat.

*Infection* was the enemy that lurked in every case whenever the surface was broken or there was a known or unknown internal focus of transmission. The use of antiseptics would be a chapter in itself, dating from the carbolic and bichloride days to the present vintage. In World War I it has been asserted that over 200 antiseptics were employed and found wanting. The Dakin's chlorinated solution of that era as administered by the Carrel technic was presumably the *sterilisia magna* sought by the ancients, and yet at Depage's Hospital at La Panne, Belgium, in December, 1917, the author soon agreed with the Belgian surgeons that this remedy was only an adjunct to the supposedly new technic of *débridement*. As a matter of fact, Dakin's solution was discarded in many military hospitals abroad before it became popularized in our own country. It is both interesting and instructive to reflect that the Dakin's solution of World War I was chemically a replica of Labarraque's chlorine preparation used a century previously. *Débridement*, that excision process by which dead or dying tissue is removed, was one of the major permanent lessons of this first war but in reality it had been used in the Napoleonic Wars a hundred years before. Baron Larrey, chief surgeon of the Grand Armée of Napoleon, popularized this technic and brought to military surgery some of its greatest permanent triumphs. Among other things, he performed over 200 amputations in the Borodino Campaign. Napoleon did not mention any of his generals in his will but bequeathed ten thousand francs to his chief surgeon and embellished this bequest by the statement: "to the noblest man I ever knew."

Experience has shown that all antiseptics have had their glamorous, colorful eras but

even to this day none of them has withstood the long period of trial and error. The outstanding lesson of experience is that surgery and not antiseptics is the factor that determines the outcome; it is what is taken out of the wound and not what is put into it that determines the outcome. This is because all organisms live and propagate on dead tissue and if robbed of this nutrient media they perish. This is the basis of débridement and we perform this surgical ritual properly if we are guided by three criteria, namely, we excise until the damaged area bleeds freely, it attains normal color and it contracts if muscle is involved. Thus, we have learned that excision of  $\frac{1}{16}$  of an inch may suffice in one patient and yet in another many inches must be sacrificed if a surgically clean field is sought. The sulfonamides of this day and generation presumably made wide excision unnecessary but this viewpoint soon proved fallacious. At Pearl Harbor, our first proving ground in World War II, we used sulfanilamide in the débrided wound and sulfathiazole systemically for the post-operative period. In addition, we rarely performed primary suture, even though many of our casualties were operated upon within what the author long ago named "The golden period" of trauma, namely, the first six hours after injury. Primo-secondary or delayed suture was the method of choice in any wound associated with bruising or severe laceration of tissue and in all fractures unless the fragmentation and soft part damage was slight. This delayed suture process means that the sutures are placed but not tied until the third day, if in the interval there are no clinical or laboratory evidences of infection. This procedure of avoiding primary suture was also a lesson derived from World War I.

In our Pearl Harbor series of operated patients the mortality was 3.8 per cent and this happy outcome was due to the early arrival of the casualties, débridement with secondary closure, the use of the sulfa drugs as indicated, liberal transfusions

when necessary and adequate after-care. However, this result would not have been attained had the skill and devotion of the surgical staff been unavailable. This group of casualties at Pearl Harbor exceeded in severity any that the writer had seen in World War I during a nineteen-month period of service abroad, eight months of which were served with the French army and one month in Belgium.

The use of sulfa drugs in fresh wounds is much more restricted now and will probably be superseded by penicillin or other antibiotics, and thus the repetition of prior experience is already in process. In our efforts to obtain the sterilisima magna we pass through a cycle of caution, then a period of great enthusiasm, then enter the zone of doubt and finally end with distrust. This has happened repeatedly in many surgical fields, perhaps most notably with antiseptics; just now the leaders in the field are penicillin, streptomycin, bacitracin and others of that basic type. We are getting away from the use of all of these in or upon the wound and rely more definitely on intravenous medication.

Experience now indicates that some of our failures are due to reliance upon any one antiseptic to overcome every type of infection. In reality, some antiseptics are relatively specific for a dominant type of organism and inert toward others. Hence, the prudent surgeon now seeks laboratory aid to confirm his opinion as to the prevailing type of infection, before assuming that his patient has a staphylococcus and not a streptococcus or mixed type of infection. This does not mean that clinical signs are to be ignored before beginning treatment, any more than diphtheria antitoxin would be withheld pending laboratory confirmation if there were suspicious throat signs. There is no question as to the value of penicillin and its consorts in selected cases, but these are not infallible and the high tide of enthusiasm is already on the wane in respect to their sovereign power in all wound infections. Again, let it be stated that experience asserts positively that there

is no substitute for adequate surgery skillfully performed at the opportune moment.

*Wounds*, not the outcome of surgical intent, are already contaminated or infected and thus are closely related to the infection problem just discussed. This contamination phase ends after the first few hours and when the six-hour, post-trauma period arrives infection is usually present to some extent. Hence, the primary care, as in so many of the traumas, determines the outcome. Experience again comes to our aid and teaches that soap and water cleansing is the best infection preventive in every type of accidental wound. This cleansing should be just as ritualistic and vigorous as the preliminary hand washing prior to a major operation. If after there are evidences of damage tissue remnants, these are removed by non-sacrificial débridement already described. Primary suture is reserved for the group seen within the golden period and in which tissue damage is minimal or removable. If in doubt, delayed suture is the preferable method; if most of the automobile and many of the industrial accidents were thus treated, the incidence of wound infection would be halved.

Tetanus and gas gangrene are relatively rare but the use of the combined prophylactic serum should be routine, if there has been an adequate source of infection and especially, if the site is in thickly muscled areas. In World War I the only indisputable surgical lesson universally accepted was the prophylactic efficacy of tetanus antitoxin. In World War II this lesson was again conceded but as yet it is too early to assess the outstanding surgical advance of this recent conflict. Perhaps one lesson will be the demonstrated value of infrequent dressings and sterile precautions to prevent re-infection while doing same.

*Burns* are still the source of much difference of opinion in regard to treatment. For many years the writer has defined a burn as a wound due to thermal, chemical, electrical or radiant energy sources. Viewed thus, the problem resembles that of any

wound and again infection looms as a prominent factor. Gone are the days in which lotions, salves, oils, tannic acid, various dyes and a host of other remedies are applied. Instead, the days have arrived in which the aim is to cleanse promptly by soap and water, gently débride, suitably cover with sterile petrolatum or mineral oil, apply massive dressings of splint proportions and let alone for seven or more days. This, in effect, is wound treatment plus the necessary antishock fluid loss precautions. Early grafting is now a standard feature and the dermatone sheet-graft has prevented such crippling and repeated procedures.

*Joint and tendon involvement* with wounds again introduces the infection element and prompt operation is the initial endeavor to rob the organisms of a place to live and abound by literally a scorched-earth campaign—cleansing and débridement. Sprains are best treated by non-restrictive strapping and early mobilization versus plaster encasement and immobilization. Synovitis and bursitis are aspirated at once and gradually increasing use becomes an early and not a late feature. Activating of adjacent muscles by self-usage is an essential adjunct, especially in the knee-joint, where the writer enjoins attention again to the statement that no knee-joint is stronger than its own quadriceps. Tendon severance continues to be a major problem and to Bunnell and others we are indebted for much valuable advice, notably as to the use of removable wire sutures applied *à distance*. To repair tendons at the wrist is one of the major problems in traumatic surgery and in this area, as in others, experience teaches that early repair means early assured recovery. After the golden period of six hours infection often interferes and wisdom dictates a waiting period of several weeks since residual hidden infection may be stirred up by operative interference. It is definitely wiser to use silk or cotton rather than catgut in tendon repair, not forgetting that inert wire also has a place. One of the outstanding advances

is the freedom with which intra-articular traumatic lesions are now approached. This applies especially to the knee-joint cartilages and ligaments. The many ingenious operations suggested for crucial ligament damage do not find many timid souls (like the author) very enthusiastic, for the good reason that most of the crucial lesions apparently repair themselves or else associated ligaments take on their function.

The writer has never operated upon a patient with this type of injury because most of them recover without tendon reefing or other types of repair. In the arthritic group the making of a new joint with a metallic or plastic capping has been notably successful in some patients, especially in the hip-joint. The present fashion is to operate very often for intervertebral lesions on the basis of disc disturbances, not only for the lumbar but also for the cervical level. These intervertebral joints are subject to the same pathologic assaults as any other articulation and to make laminectomy the first rather than the last choice does not appeal to the author as prudent therapy. Pain in the back is due to many causes and operation should not be undertaken by the inexperienced or the occasional operator.

The diagnosis of the disc syndrome is essentially that of an intraspinal tumor; and if the neurologic symptoms are lacking, operation can be exceedingly harmful. It is not good surgery to inflict by operation a very real type of pathologic condition in an attempt to cure a suspected type of disorder. Disc disturbances can often be cured without operation, just as knee-joint discs (the semilunars) are frequently amenable to non-operative relief. The analogy between the knee and the interspinal cartilages is very close from the standpoint of causation, symptoms and pathology. Even in the experience of the best known neurosurgeons the successes do not often exceed 50 per cent, not forgetting that many times the relief by disc removal is dramatic and sustained. The experienced surgeon in this spinal area is unusually

cautious in selecting his patient, knowing full well that in the compensation or legal group success may not be attained, even though the findings and the operative result might register success if this and allied medicolegal angles did not exist. Trauma incidental to the ordinary accidents of leisure or sports registers in a regular pattern, but when the responsibility for an identical mishap can be placed on some one else, the situation becomes fogged and a host of subjective complaints that rarely are actually related to the injury in question appear. Experience amply denotes that only a so-called "lump settlement" is the healing balm that often supersedes the most skillful surgical management. Morale is so often lacking in this zone of compensable injuries that the surgeon in attendance or the consultant is beset by a chain of circumstances entirely foreign to the trauma and one that presents a pathologic condition that has come to be known as "compensationitis."

*Fractures and dislocations* therapeutically are very much in evidence, especially the former in respect to so-called newer forms of treatment. We are again passing through a phase in which operation is given the first, instead of the last place in therapy. The gadgeter in traumatic surgery has a field day in many types of injury, but in fractures some of the recommendations resemble those that could be found in Popular Mechanics, rather than in a standard surgical treatise. There is nothing essentially new in the current models of plates, pins, screws, bars and wires because the majority of these are but streamlined modifications in use half a century or more ago. Pinning of the hip is an exception to this commentary and so is the judicious use of nails or screws, but the vice is that the use of indwelling metals is a surgical fault and negates the age-old precept that the tissues do not willingly tolerate foreign bodies. The vast majority of fractures can be managed by non-operative measures and failing this, skeletal traction is an efficient and safe procedure if any tissue invasion is

necessary. The present teaching of converting an ordinary simple (closed) fracture into a compound (open) fracture to obtain better alignment with a more or less complicated metallic device is not without danger, even in the hands of skillful proponents. Bone infection is osteomyelitis and as yet we have not passed the stage where the old adage "once an osteomyelitis, always an osteomyelitis," can be disregarded or discarded. A fracture is a wound of bone, and here again as in all types of trauma, infection is a foe to reckon with whenever adjacent covering is damaged or torn.

The author does not mean that we should cling to old methods in fractures or any other effect of trauma, but it is firmly asserted that the experienced do not operate unless other less hazardous and equally effective measures are found wanting. Complacency has no place in progressive surgery but conservatism has always been a guiding principle and should still prevail. Years ago when plating was the vogue a great many surgeons were able to report initial successes; however, the tide turned when non-union, osteomyelitis and amputation appeared with too great frequency. Already some of the vaunted current operative procedures have succumbed in the flames of the crucible of experience and others are in the process of flickering.

*Anesthesia* is one of the great allies in traumatic surgery and the progressive development in this phase has been remarkably consistent. Here again another specialty has been created to replace the willing but relatively incompetent service rendered by a confrere. Many of the newer anesthetic agents have passed through the stage of trial and error and now can be used with safety and accuracy. It is axiomatic in traumatic surgery that any procedure should first of all be safe and next it should be simple. The need for an anesthetic that would provide safe, complete relaxation for a short period has long been in demand. If, in addition, there were such desirable features as freedom from a stage of excite-

ment during induction, recovery and prompt return to full consciousness without nausea and vomiting, then indeed would such an agency be welcomed. For painful dressings, incision and drainage, the reduction of fractures, dislocations and many other emergencies, a safe, easily administered agent is often demanded. Intravenous anesthesia has been the answer and now the use of pentothal has become a standard method and in many cases it is a safe agent for prolonged administration and is also useful as a preliminary procedure to inhalation methods. However, the simplicity and certainty of its application should not lull us into complete security, and at all times oxygen and coramine (or the equivalent) should be readily available.

*Neurologic surgery* has advanced appreciably, especially in regard to intracranial operations in which the electrocoagulation technic has measurably averted one of the greatest dangers, namely, hemorrhage.

There is no uniformity of opinion as to the feasibility of peripheral nerve transplantation but there are an increasing number of reported successes in this important sphere. The repair of a damaged spinal cord is yet beyond our reach and thus the outcome in the post-traumatic paralysis following vertebral fracture continues to be tragic. However, much is being accomplished by active rehabilitation measures in spinal as well as in other serious injuries. The principle of self-aid is now properly being stressed so that the cooperation of the patient has become a main factor. It is too often forgotten that baking, massage and other physiotherapeutic measures were originally intended only for the disabled patient; the current tendency is to provide the necessary neuromuscular tonicity by physiotherapy rather than by the cooperative activity of the patient. This process is not only habit-forming but it also lowers neuromuscular tone and general morale. The many electrical devices now employed without adequate indications add to the confusion, and this is especially so in respect to the so-called short wave and long wave

treatments; indeed, many of these are so endlessly given that they deserve the name permanent wave.

*Occupational surgery* has made great strides and medical men in industry have enhanced their reputation measurably, especially during the recent war years when our mechanical age was providing peak production. The follow-up available in industrial organizations provides the best in end results because the control of the patient is more definitely assured than in private or hospital practice. This branch of our profession has evolved in startling fashion and now recruits a very high grade instead of the mediocre participant who drifted into this arena because he was unsuccessful elsewhere.

This cursory review seeks to indicate that collective experience is the foundation of traumatic surgery, just as it is in every branch of our profession. Methods should and will continue to be presented for the better treatment of the injured who now comprise a very large percentage of private and hospital patients. The aviation age is here, and with it many variants of trauma are already evident and these will continue to test the skill and adaptability of those who deal with traumatology. The general practitioner is often the first line of defense in trauma and his initial treatment is often a main element in the outcome.

We must not be too prone to accept loudly acclaimed methods unless authorized by those who have earned by experience the right to act as our guides and mentors. Conversely, we must not be complacently conservative and become bound to outmoded practices. There are new models in traumatic surgery and it is our duty to accept advances if properly authenticated. The gadgets in traumatic surgery are limitless, some of them are excellent but many are of no value and occasionally are harmful. There are still many unsolved problems in trauma, even though this branch of surgery has the most ancient background of all the an-

cients. In the days of the pyramid builders fractures of the femur were very frequent and just as troublesome as those of our generation. Fracture of the os calcis is now probably the most common problem fracture and despite a dozen or more methods advised no treatment is uniformly applicable or successful. There is, as stated, an awakened interest in trauma on the part of all surgeons and this will continue to increase our knowledge to the end that the injured will receive a still higher grade of care and attention.

Traumatic surgery is the most generalized type of surgery, in that any section of the body may be affected by injury. For this reason a traumatic surgeon should have skill and experience sufficient to meet any emergency, inasmuch as trauma is no respecter of persons or of any anatomic zone. A fracture of the pelvis may be complicated by a urologic problem, rib fractures may be associated with intrathoracic damage and a stab wound of the abdomen may demand the skill of an abdominal surgeon. Thus, a traumatologist needs a background of knowledge and experience and be prepared to render effective aid for any emergency.

The past and the present of this subject with some of the accepted and discarded phases have been discussed and naturally a preview of the future is in order. Routine standardization probably will never be attained because of the varying circumstances surrounding severe or multiple injuries. The presence of shock and hemorrhage may negate definitive early care, as will prevailing circumstances and constitutional or age factors. A fracture of the femoral neck in a feeble octogenarian or a severe burn in a child may make it impossible to apply the routine management in the early stages. The presence of cardiorenal, vascular, diabetic, mental or other preceding disease processes may make prolonged incumbency undesirable and utterly upset a schedule indicated for the injury itself. Thus, treatment of the person takes

precedence over the treatment of the injured part and again features the diverse variants of trauma.

An outstanding need for the future is the realization that trauma is an emergency and that a broken thigh is entitled to the same immediate attention as a ruptured appendix. Every hospital should be so staffed that the injured patient is accorded the same early care now available for many types of general surgery.

Substantial progress has been made in the past decades and this fortunately applies to the 80 per cent group of injured already discussed.

As indicated, it is too early to appraise the actual war gains that may be transferred to civil practice, but the outstanding fact that the attention of so many of the profession was focused on trauma cannot fail to have lasting value. Thus, the summation of these experiences in trauma may again be said to revolve around the idea that now, more than ever, our confreres are injury conscious and alive to the needs of the victims of trauma. The postwar period is already demanding increasing plastic repair and advanced rehabilitation procedures that will be useful also in civil practice.



No injured person should be moved until his wound has been dressed and the fracture has been immobilized securely. . . . Calmness and the avoidance of unnecessary haste are important, and rough and unnecessary handling should be avoided.

From "Fractures and Dislocations for Practitioners" by Edwin O. Geckeler (The Williams & Wilkins Co.).



# CAUTION IN HANDLING THE EXTENSIVELY INJURED

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THE development of high powered machines, work at heights and in depths, have increased the magnitude of injuries both in gravity and multiplicity. Knowledge of methods of treatment and laboratory control has been improved so that persons with severe injury can sometimes be saved who would formerly have died. The human being cannot stand unlimited trauma. With the extensively injured no rules can be laid down to cover all cases, but there are certain principles to guide us in doing first things first, thereby not adding surgical trauma until it can be tolerated and not delaying reparative surgery until the progress of infection becomes more than the body can cope with.

We are presented with a patient with a definite serious injury which demands our attention. Is this the only injury he has or even the most important one? A few minutes spent in trying to learn the mechanism of accident may save the patient's life. A fall in an elevator may result in fractures of the os calcis, above ankle or at knee, the vertebral bodies or the base of skull, or any or all combined. The os calcis fracture is evident, but to disregard the other possibilities may mean that a simple compression fracture of the lumbar spine will produce a cord injury, possibly irreparable, in moving the person to or about the hospital. If the mechanism of accident has been such that severe injuries may have been produced, treat this patient as though these injuries have occurred until it has been possible to examine him thoroughly enough to rule them out.

Suppose a person's trunk has been caught between the rear end of a truck and a wall, or by a rock fall in a tunnel. He is dazed but not in too bad shape. Ribs may have been broken puncturing pleura and lung, intercostal vessels may be bleeding in-

ternally, anything may have happened within or surrounding the abdominal cavity, including spinal injury. There may be little sign of anything definite when first seen, but the mechanism of injury has been such that it would seem that severe injury should have resulted. Handle him as if this is the case until all severe injuries can be ruled out following various tests at a time he is able to stand them. Protect the patient from all further trauma until possible injuries have been disproved rather than consider that he was fortunate not to have been hurt worse. If a history is obtainable from the patient or bystanders, this history may mean using a few moments which will save life. Also remember that while stories of sudden occurrences may often vary greatly, still they may give an idea of what might have happened.

Ambulances are rarely manned with doctors. It would be a waste of trained man power if they were. By the same token it is a public responsibility to insist that ambulance crews of all types—morticians, private ambulances, police and fire departments, industrial, hospital—shall have the minimum training of a Red Cross First Aid course. For the extensively injured person this amount of training may make all the difference between life and return to employment or permanent disability or death. If speed of the ambulance only is the first consideration the border line case will usually be lost anyway.

Is there possibly an injury to the cervical or lumbar spine? If there is, an unparalyzed patient may be and often is converted into a completely, permanently paralyzed person merely by the method used in first lifting him from the ground. It is inexcusable for an ambulance crew to be unaware of the safe method of transporting possible spine injuries. The injured person is bleed-



ing from an extremity. Shall a tourniquet be used? Indications for it are readily learned by any layman. Improper use, or less commonly failure of use, may make the difference between life and death. Traction splinting of lower extremity fractures at the site of accident may lessen the amount of shock in the person with multiple injuries just enough to turn the tide between a dead and live patient later. With over a million accidental injuries annually, 150,000 doctors cannot be present when they happen. We should be responsible for knowing that the ambulance situation in our own community is covered by persons with at least a minimum of training.

The method of examining the extensively injured is of great importance to him. If not in shock, the patient probably will be in a short time. Do not wait for the blood pressure to fall before instituting shock treatment as this is a sign that shock is already far advanced. Give morphine to relieve pain, except in brain injuries, and give enough to relieve it. If he is cold, warm him up and keep him warm, but this does not mean piling on hot water bags and blankets until he is bathed in sweat and losing precious fluid. He needs a transfusion. Obtain the blood and cross matching at the earliest moment, but have plasma running in the meantime. This will help prevent or relieve shock and will not waste time getting a needle into a vein when blood is ready. Remember whole blood is the fluid really needed in traumatic shock, except from burns, whether there has been evidence of loss of blood or not. Administration of too much fluid can be as dangerous as too little. Frequent checking of the specific gravity of the blood or the hematocrit is needed to furnish the right amount.

Hemorrhage must be stopped. Proper pressure application is almost always sufficient for external bleeding. Preventing further bleeding is nearly as important as replacing the blood lost already.

Shock and hemorrhage must be considered first. Further treatment cannot be rendered except on a live patient. Next and

accompanying it as far as possible is the physical examination. It must be gentle and without undue exposure in order not to increase shock. Which are the immediately important fractures? Is there a possible abdominal or chest injury? With signs of possible abdominal injury we must consider the solid organs, liver and spleen, the hollow viscera with possible perforation, the blood vessels, e.g., mesenteric, the retroperitoneal organs—kidney, adrenals, retroperitoneal hematoma, spine and spinal cord, perforation of the diaphragm, etc. We must decide whether any operative procedure is indicated at the first possible moment, which part of the body will be approached first when the condition improves sufficiently to do anything, whether no marked improvement can be expected in the general condition until some intervention has been accomplished even if the person dies in the attempt. These decisions may need to be changed as the condition changes, but we must constantly keep in mind doing first things first. There is no use applying skeletal traction for a fractured femur and spending time carefully arranging traction suspension when we believe the abdomen must be explored at the earliest possible moment, requiring the taking down again of the traction apparatus. Rather keep the part in emergency traction until decision is made regarding the abdominal trauma.

X-ray examination is often carried to a ridiculous extent. What films do you absolutely need to determine what you will do to the patient first when possible and what will prevent further injury in the meantime? Demonstration of free air below the diaphragm may prove rupture of a hollow viscus. Examination for this is of little use unless the patient is in the upright position. The presence of a vertebral column injury may need to be proved before the patient can be supported in the sitting position without danger of spinal cord damage. However, the use of a tilt table allows the examination for free air without endangering the spinal cord.

Too many early x-rays of the skull are taken. Unless the patient is cooperative enough to keep his head quiet, these should be postponed unless one believes it is absolutely necessary to determine the presence of a compound depressed fracture or a fracture at a site which could readily produce an injury to the middle meningeal artery. Otherwise no operative intervention on the skull is going to be instituted early anyway and x-rays for the record may better be done later.

The presence of fractured ribs proved by x-ray will usually make little difference in early operative treatment. There may have to be treatment for pain on breathing, for tamponade of the lungs with blood, for paradoxical respiration or tension pneumothorax, but time and effort spent on x-ray of the chest offers little in the early care of the extensively injured that can not be learned equally well or better by the physical examination. Anesthetizing the proper intercostal nerves may often change the picture entirely in a patient suffering severe chest pain.

Beds in the admission ward are a practical necessity in these cases. Close supervision is necessary. Many patients suffer further injury and exposure in non-medically supervised movement from stretcher to x-ray table, ward bed or operating table. For an orderly to undress a patient behind a screen often constitutes an acute danger. It is better to cut off a good shoe than to make a simple fracture of the leg compound in attempts to pull it off. Coats and pants are much better cut for removal if movement might in any way endanger the patient. Critical time is lost in moving to a ward, etc., which should be employed in getting plasma and blood into a vein. Do not be satisfied with *ordering* fluids but *know* that they are commenced immediately.

With fluid running and the advisable amount of preliminary examination completed, orders must be written so that assistants may be certain of the sequence in which they are to carry out examina-

tions and treatments. With no traction applied before coming to a hospital, naturally fractures requiring immobilization in emergency traction should have this done before plaster immobilization is applied to other fractures. If you wish pulse and blood pressure recorded every fifteen minutes or half hour, see that some one is delegated to do this without making a doctor temporarily discontinue a more specialized part of the treatment. In an unconscious patient does your order for urine specimen mean when he becomes conscious and voids voluntarily, attaching a container for involuntary voiding, or immediate catheterization to learn whether there is difficulty in passing a catheter into the bladder or if the urine is full of blood or sugar? You examined the patient and your order must be framed so that your assistant has some idea of its immediate importance and what you are looking for. There is nothing rational in ordering for the extensively injured patient x-rays of all bones which your examination shows might possibly be fractured and not stating which, if any, must be done immediately to guide treatment at the moment. Do not expect the x-ray technician to read your mind or ask him to kill the patient by taking immediate pictures of most of the body. It must be your decision whether an x-ray finding may change the treatment in the next few hours for this critically injured person or whether he should be disturbed as little as possible.

Wounds should be cleansed, excised if indicated, and sutured as early as practical. Much loss of time and possible infection will be saved to the patient if he gets well, but this work must not endanger his life further by increasing shock or taking an assistant from more necessary procedures.

Hemorrhage must be stopped and an open chest wound closed immediately. Evidence of intra-abdominal perforation calls for operation as soon as the general condition is improved sufficiently to stand it. Otherwise there are few conditions that require operation until recovery from shock

## Kennedy—Handling the Injured

seems quite definite. With sufficient help in the form of operating teams and trained laboratory assistants to handle the need for and introduction of fluids, operations can often be done much earlier keeping shock under control during the procedures rather than knocking a person down again by operation as soon as he has recovered from shock the first time. This is only true where a large trained personnel is available and a special shock team takes entire responsibility for the general condition of the patient.

Many details of treatment or examination make much difference in the survival of these patients. Some examples follow: Most cerebral injuries show some lack of oxygenation from respiratory depression. It is advisable to commence oxygen inhalation in all patients unconscious from trauma. With a cerebral injury and unconsciousness, but no evidence of injury to the gastrointestinal tract, a Levin tube through the nose from the first can supply the needs of fluid and nutrition largely rather than continuing intravenous therapy over a number of days. It is too often forgotten that unconscious patients are likely to starve to death. If a foreign body is projecting from any part of the body, do not remove it until the operating room is ready and the patient is in shape for operation. Too often the foreign body is plugging an injury in a large vessel with danger of fatal hemorrhage on removal unless all is ready to stop it. Abdominal paracentesis, when positive for blood or air, may be the simplest method of making a decision that abdominal exploration is necessary at the earliest possible moment. Formerly if one was fairly certain of a diagnosis of rupture of the liver the abdomen would not be opened for this reason only. As soon as the peritoneum was opened and intra-abdominal pressure released, hemorrhage was likely to start up so severe that death occurred before the wound in the liver could be sufficiently plugged with gauze. Now with the introduction of non-absorbable coagulant material and massive trans-

fusion rupture of the liver should be handled in the same way as hemorrhage elsewhere. Never forget that evidence of a ruptured spleen may not appear for several days after injury. It must always be kept in mind when there is possible trauma to the lower thorax and upper abdomen.

Blood in the urine may come from any part of the urinary tract from kidney through urethra and in contrast there may be a clear urine with a complete rupture of the ureter at any point from the pelvis of the kidney to the bladder. In general, injuries to the kidney should be treated conservatively and non-operatively whether simple contusions or fragmented kidneys. An intravenous pyelogram is often of great value in determining fairly early the extent of the lesion. On the other hand rupture of the bladder or urethra requires radical operative treatment as early as possible before infection sets in. An intravenous pyelogram is much safer, if the diagnosis cannot be made otherwise, than any injections of opaque substances or air through the urethra.

Rectal injuries with possible perforation demand early colostomy as the most conservative procedure. Arterial spasm in any severe injury of the extremities is common and evidence of this must be watched for and often relieved by paravertebral block. A procedure, such as open reduction and internal fixation of a compound fracture, might be advisable if this is the only injury, whereas in multiple injuries it might be foolhardy from time consumed or from the danger that infection may set in some of the other injuries and later affect the fracture site through the blood stream; conversely, other injuries may be of such a nature that it appears absolutely necessary not to immobilize the extremity and internal fixation becomes advisable in spite of the danger of infection. If a person has been in the Armed Forces since the beginning of the last war he should be given 1 cc. of tetanus toxoid for any open injury, not antitoxin. It is safe to assume that he had his original injections and his

booster dose after one year. It is considered that for at least five years thereafter any injury requires only another booster dose. Severe reactions to tetanus antitoxin are common, so toxoid should be used when the person has been recently immunized. When there is occasion to administer considerable amounts of glucose, remember it is useless if spilled in the urine and should rather be covered with the use of insulin. A person not receiving food by mouth can be kept alive as far as nutrition is concerned almost indefinitely with intravenous protein hydrolysates, glucose, fluid and vitamins. The person with extensive injuries needs two to five times as much protein intake as the normal and will not do well without it.

#### SUMMARY

The extensively injured need to be handled in a different manner from the person with a single injury of lesser degree. On account of more marked shock every effort must be made to protect them from

increasing this and to combat it promptly. Since they will not tolerate too much being done at once great judgment is needed to do "first things first." Possibly one's main interest is centered in a particular field of surgery. One must not become too engrossed in treating one part and forget the whole man. Organization and team work are required if such persons are to be given the best chance. The importance of history, transportation, treatment of shock and hemorrhage, thorough, brief and non-traumatic physical examination is reviewed. Instances of detailed care of parts so that the whole man can be reconstructed promptly are cited. More of these patients will be saved if caution is used in the amount done, keeping in one's mind the order of importance of the various problems. If an operation is necessary all efforts must be exerted toward getting the patient ready for this at the earliest possible moment. Meantime the less acute injuries may not be neglected, lest complications set in which will make these the last to get well.



# ROENTGENOLOGY OF THE SPINE IN INDUSTRY

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THE interest of the industrial surgeon in the spine centers on traumatic lesions, structural weaknesses and post-traumatic conditions which will be discussed in the following order: (1) Fractures and dislocations; (2) invisible traumatic lesions; (3) (post-traumatic conditions) and (4) roentgen demonstration of vertebral abnormalities.

## FRACTURES AND DISLOCATIONS

Dislocations in the spine are usually accompanied by fractures. The roentgen features by which these conditions are recognized are altered relation of parts for dislocations and, for fractures, changes in shape or size of vertebrae, displacement of fragments, solutions of continuity and, later, development of callus.

*Compression Fracture.* Most fractures in the spine are of the compression type. They may be produced quite easily, especially in older people. Merely lifting a heavy object may be sufficient trauma to fracture a vertebral body. Sudden flexion of the spine is also an adequate force, and falls in which the patient lands on the feet, knees, buttocks, back or head readily result in compression fracture of vertebrae.

Such fractures should be looked for after any such trauma if there is localized pain in the back and even when there is no complaint of back pain if other parts are injured which may distract the attention of the patient away from the spine as, for example, when a calcaneus is fractured by landing on the feet or when there is multiple bruising in a rolling fall, as from a horse.

Compression fractures are usually single but may occur in widely separated portions of the spine. For this reason, the entire spine should be examined when compression fracture is present. If more than

two vertebrae appear fractured, the possible presence of a pathologic fracture should receive special consideration. However, the pathologic conditions most commonly leading to multiple compression of the vertebral bodies, such as malignant tumor or post-menopausal osteoporosis, occur at an age which is beyond the usual age of industrial patients.

*Shape of the Fractured Vertebra.* Compression of the body of a vertebra by fracture usually produces a characteristic deformity (Fig. 1) which is the chief means of differentiating compression fracture from other lesions roentgenologically. Typically, only one-half of the vertebral body is affected, usually the superior half. The fracture line extends from the superior posterior angle of the vertebral body to a point on the anterior surface slightly above its middle. There is increased density along this line in the fresh fracture due to impaction of the fragments. The superior surface is broken anterior to its middle, forming an anterior and a posterior fragment. The anterior fragment is less depressed anteriorly than posteriorly. This causes angular concavity of the superior surface with the apex of the concavity at the junction of the fragments. The anterior fragment is forced slightly anteriorly relative to the inferior portion of the vertebra and thus forms a slight projection in the anterior surface of the vertebra at the anterior end of the fracture line.

These features, the fracture line, the impaction, the superior surface and the anterior surface are characteristic for compression fracture individually and collectively. The deformity persists and is still characteristic after union and thus enables differentiation of old compression fractures from other deformities.

In post-menopausal osteoporosis with

spontaneous collapse of vertebral bodies deformity of the vertebral body is usually multiple and progressive. The anterior surface of the body appears intact. Superior and inferior surfaces are excessively concave but the concavity is rounded not angular. The intervertebral disks are correspondingly more rounded and deeper; they approach the spherical shape. The vertebrae are undercalcified. The patient has passed the menopause (natural, artificial or pathologic). Of course, additional traumatic compression fracture may occur with slight injury in this condition and add the features of compression fracture to the other changes.

Shallow biconcave vertebral bodies in chondrodystrophy present no angular deformity of the horizontal surfaces and no projection in the anterior surface. The shallowness is notable throughout the vertebral body and many vertebrae are about equally involved.

In the case of tumor the vertebral body is decreased in density or contains rounded areas of increased density. Areas of bone destruction and soft tissue mass may be visible. Fracture may occur and add the typical features of compression fracture to the other changes.

Usually the residual of adolescent wedging round back ("epiphysitis") is multiple and confined to the dorsal region. Both the upper and the lower halves of the vertebral body are usually involved in the wedging. The superior and inferior surfaces of the body are intact and not excessively concave. The anterior surface presents a dimple at the central plane of the body and there is no projecting fragment in its superior half.

A moderate degree of wedging may have developed anteriorly in the dorsolumbar area or posteriorly in the lowest lumbar vertebra in normal spines. This may be somewhat exaggerated in residuals of rickets or localized chondrodystrophy. In these conditions the deformity of the anterior and superior surfaces typical of compression fracture is completely lacking.

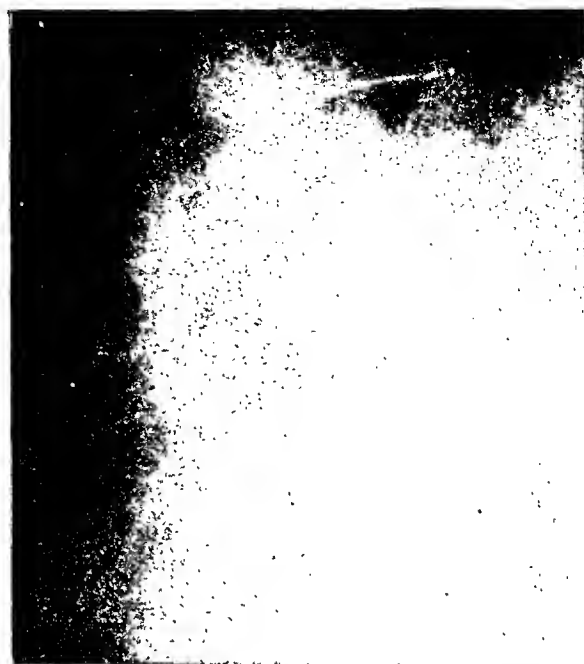


FIG. 1. Compression fracture of a vertebral body. This case exaggerates and therefore emphasizes the characteristic features of the deformity.

This also applies when a vertebral body has become wedged by growth disturbances in connection with fused ribs or incomplete segmentation of the vertebral bodies.

The anterior and the horizontal surfaces are convex in hemivertebra rather than concave and lack the characteristic deformities of compression fracture. The anteroposterior diameter of the body is short. The intervertebral disks and adjacent bodies are deformed to conform to the shape of the affected vertebra.

*Size of the Fractured Vertebra.* The vertical diameter of the vertebral body is decreased anteriorly in compression fracture but the horizontal diameters may be increased. These changes are not diagnostic for fracture but are mentioned to contrast them with some other conditions. In all of these other conditions the characteristic shape of a fractured vertebra, which has been described, is lacking.

In Paget's disease and benign tumor all the diameters of the vertebral body may be increased but there are decreases of density or variations in density or texture which are foreign to fracture.

The vertical diameter of the vertebral body in chondrodystrophy is narrowed but the horizontal diameters are increased.

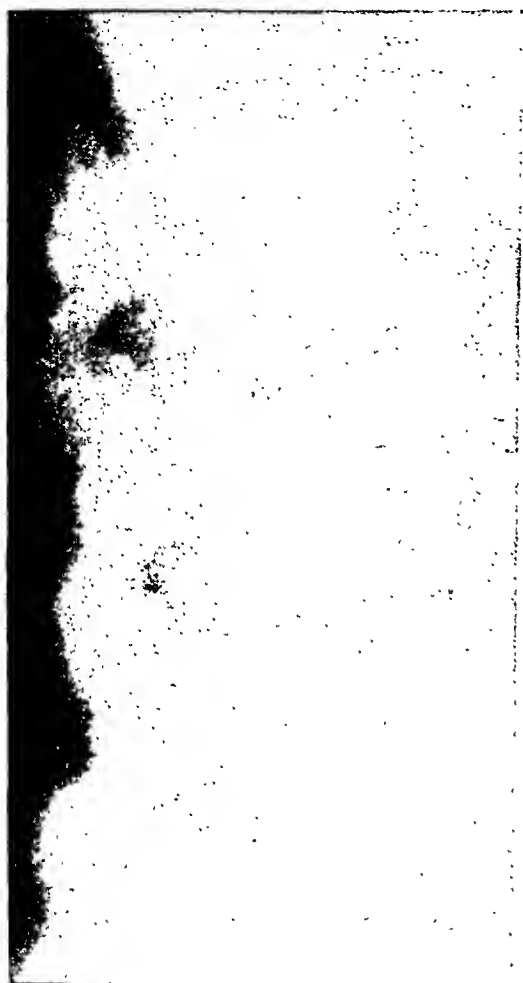


FIG. 2. Accessory ossification center at the anterior superior angle of the vertebral body. The junction with the body has been traumatized causing production of post-traumatic calcification inferiorly.

The whole of the body is affected and most of the vertebrae show about the same degree of change.

The anteroposterior diameter of vertebral bodies may be broadened by developmental influences. Examples are found in the superior surface of the sacrum in spondylolisthesis and in the inferior surface of the fifth lumbar vertebra in posterior prominence of that vertebra. In these conditions neither the anterior nor the horizontal vertebral surfaces show the deformity of compression fracture. If there has been resorption of the anterior angle of the sacrum in spondylolisthesis, the superior surface of that vertebra is convex not concave. The increase of the antero-

posterior diameter in these conditions occurs during the years of growth. In legal cases, the increased diameter of the superior surface of the sacrum in spondylolisthesis may be used as positive evidence that the condition dates back to childhood.

*Other Fractures.* Fractures other than compression fractures are to be recognized roentgenographically by the diagnostic characteristics of fracture lines and of fracture fragments and by displacement of fracture fragments. Not all fractures are recognizable. Many fissure fractures, especially in the coccyx, the sacrum and the vertebral arches cannot be seen in the roentgenogram even though surgery or autopsy has demonstrated their position. In this connection two facts become particularly important: First, one must never assume that there are no invisible fractures in the arch of a vertebra which may endanger the patient if surgery or reduction of a compression fracture are to be attempted. Second, further roentgen study of the spine should always be planned if it is important to identify, for legal or other reasons, all of the fractures which may be present in a given spine. Additional views from new angles may reveal a fracture previously invisible. Resorption along a fracture line may cause a fracture previously invisible to become visible in four to six days. The development of visible callus in three or more weeks may yield evidence of a fracture previously invisible.

*Fissure Fractures.* The diagnostic characteristics of a fracture line serve to identify fissure fractures and may also be used to confirm the interpretation in fractures with separation or displacement. The fracture line is to be distinguished from the developmental division (cartilage line) but it should be mentioned in passing that the developmental division may, of course, be traumatized. Such traumatism may be suspected if the surfaces of the cartilage line are far from parallel to each other and may be regarded as demonstrated if visible callus appears at the margins of the cartilage line in a few weeks. (Fig. 2.)



The fracture line is a line of division in bone at which the bone surfaces are spiculated (if fresh) and irregular, the width of the line is irregular and the margins of the line are angular.

The cartilage line is a line of division in bone at which the bone surfaces are smooth and regular and the width of the line is approximately equal throughout with its sides parallel to each other and the margins of the line are rounded. Several of the conditions in which the cartilage line is seen will be mentioned after the discussion of the size of fracture fragments.

*Size of Fracture Fragment.* The important point about the size (and, to some extent, the shape) of a fracture fragment is that it should fit the defect in the bone from which it has been separated. If one imagines the two pieces of bone to be fitted together, a bone of normal size and shape should result. In contrast to this, it is almost universally true that an accessory ossification center presents not only a division of bone but also a greater quantity of bone than would normally be present. If one imagines the ossification center to be fitted to the main body of the bone, the resulting mass would be larger than a normal bone and would vary from the normal shape. Consideration of this fact, together with the presence of a cartilage line, serves to differentiate accessory ossification centers from fissure fractures.

Conditions in which a cartilage line or an accessory ossification center are present include the following: (1) Spina bifida: some bone is lacking (the spinous process). If the space between the laminae is small, the line of division is a cartilage line. (2) Free spinous process: some bone is lacking;—the spinous process is represented only by a rudimentary ossicle which is sometimes mistaken for a fracture fragment. The laminae are not united to the rudimentary spinous process. The space between the lamina and spinous process may be wide as in spina bifida but if it is narrow the line of division is a cartilage line. This condition is common at the lumbosacral junction. (3)

Failure of union of a pedicle to the body or of a lamina to the spinous process or to the pedicle: The defect is a cartilage line. At the first cervical vertebra such defects may be difficult to see with sufficient clarity to distinguish clearly between the cartilage line and the fracture line. Underdevelopment of bone adjacent to the defect may be sufficient to suggest the developmental nature of the condition. More often, absence of swelling of the soft tissues anteriorly as outlined by air in the pharynx may be relied upon to indicate that the lesion is not a fresh fracture. Swelling of the soft tissue in that area regularly follows fracture or dislocation in the upper cervical spine.

(4) Bilateral failure of union of the laminae to the pedicles: This is the defect which permits spondylolisthesis. It is most common at the fifth lumbar vertebra. Forward slipping of the vertebral body increases separation at the defect and motion between the separated parts is a chronic irritant which results in irregular resorption and deposit of calcareous matter. Consequently, the defect may not clearly have the appearance of either the fracture line or the cartilage line. When the condition is sufficiently advanced to cause this difficulty it has had other effects, such as underdevelopment of the vertebral arch and increase of the anteroposterior diameter of the body of the first sacral vertebra, which identify the condition as a developmental lesion and distinguish it from fracture.

(5) Rudimentary rib: The twelfth dorsal or first lumbar vertebra frequently bears a rudimentary rib. The line of division is a cartilage line which is usually somewhat rounded with the convexity laterally. The vertical diameter of the rib is usually greater than that of the adjacent portion of the transverse process. Cervical ribs are rarely sufficiently rudimentary to be confused with a fracture fragment except in the age period from three to six years. Most of these are temporary but if they remain divided from the transverse process at the



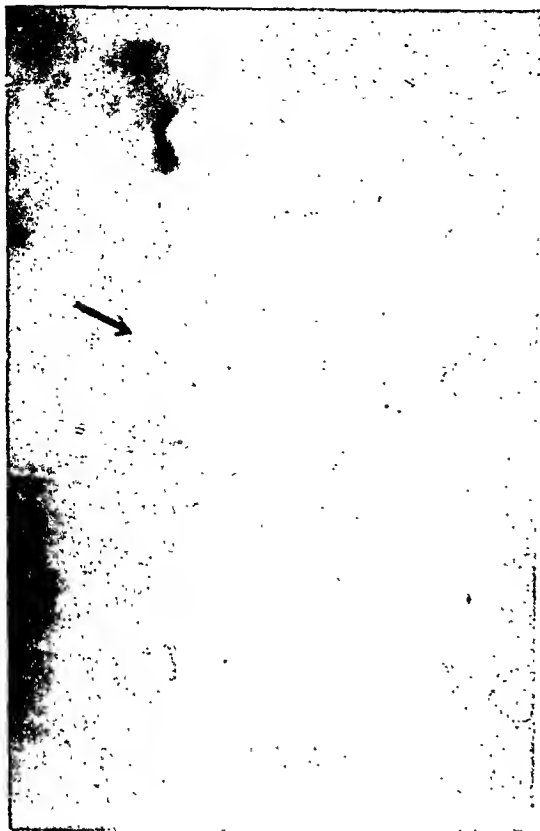


FIG. 3. Post-traumatic arthritis. A single vertebra exhibits calcareous lipping at the margin of the disk.

age of eight years they will persist. In them, the line of division is a cartilage line.

(6) Accessory ossification center at the tip of a vertebral facet: This is most common in the mid-lumbar region and at an inferior facet. The line of division is a cartilage line. The size of the facet, including the accessory center, is usually larger than normal as judged by neighboring facets.

(7) Accessory ossification center at the angle of a vertebral body: This usually affects the anterior superior angle of the vertebral body and is most common at the fourth lumbar vertebra. It is often mistaken for fracture. The line of division is a cartilage line. In whatever way the ossicle may be imagined to be fitted to the vertebral body, the resulting vertebral outline would be larger than normal and would vary from the normal shape. If traumatism has sprung the cartilage line (in this or other anomalies), callus may appear in a few weeks

at the margins of the cartilage. Such callus is illustrated in Figure 2. The callus is evidence of the traumatism.

(8) Double hemivertebra: In this instance, the two portions of bone together do not equal the size of a normal bone. The line of division is a cartilage line. The bone margins are much rounded. Adjacent bones are somewhat deformed to conform to the deformity.

(9) Osteophytes: In chronic arthritis, osteophytes may be formed which are not continuous with the vertebral body and such formations may be mistaken for fracture fragments. There is no visible defect in the vertebral body from which a fracture fragment could have been derived. The supposed fragment cannot be imagined to be fitted to the vertebral body in any way which will yield a vertebra of normal size and shape.

(10) Calcification or ossification in the interspinous ligament: When such ossicles occur at the ligamentum nuchae they are not infrequently mistaken for fracture. There is no defect in a spinous process from which a fracture fragment could have been derived. The ossicle cannot be added to the spinous process to form a bone of normal size and shape.

*Displacement of Fracture Fragment.* In contrast to the accessory ossification center, the displaced or separated fracture fragment is derived from a bone of normal size and shape and can be imagined to be refitted to that bone to restore normal size and outline. If the defect from which the supposed fracture fragment is derived is not visible, it may be sought in additional views from new angles. If it still is not evident, the diagnosis must be regarded as uncertain; if the fragment is more irregular than an accessory ossification center and presents no cartilage line, it may be calcification following an ancient strain or healed fracture instead of a fresh fracture fragment.

Fracture fragments may be derived from the vertebral body in several ways. The fragment at the anterior superior portion of the body in compression fracture

has been described. Vertical split of the body may form large fragments. A portion of the apophysis may be elevated from the body by avulsion anteriorly by extension, posteriorly by flexion.

The most commonly visualized fracture in the vertebral arch is the fracture of a transverse process by avulsion. The spinous processes are subject to fracture by avulsion and by direct violence. Compression fracture may be accompanied by horizontal fracture across the posterior portion of the arch with vertical separation of the fragments. Other fractures in the arch are more difficult to see and many of them may be invisible. Careful inspection should be made for possible displacement of a fragment into the neural canal where it may have caused damage to the spinal cord or be a potential danger to the cord if manipulation is to be attempted. Oblique views may prove very helpful in this inspection.

*Fracture Dislocation.* Fracture dislocation is not a uniform entity but rather a combination of some fracture with an evident dislocation or of some degree of dislocation with an evident fracture. In the presence of the one condition, evidence of the other should be sought.

In the dislocation of one vertebra on another the displacement is often facilitated by fracture of the facets of the inferior vertebra. Careful inspection, especially with the aid of oblique views, will prove that the facets are not intact. When the facets are intact there is often fracture at the anterior superior portion of the inferior body by compression or by avulsion. Fracture of the odontoid process often accompanies dislocation of the first on the second cervical vertebra. A small chip fracture produced by avulsion is often present at a sacrococcygeal dislocation.

When dislocation accompanies fracture involving a vertebral body the posterior superior angle of the inferior body may encroach upon the neural canal and lie in close relation to the laminae of the superior vertebra. This close relation should be looked for as it constitutes a source of

injury and compression of the spinal cord and a danger in the event of attempted manipulation.

In compression fracture the spinous process of the affected vertebra is separated from that of the superior vertebra toward its tip by flexion. With this relation of spinous processes there may or may not be dislocation but with any other relation of spinous processes fracture dislocation should be present. The superior facets of the inferior vertebra may be fractured or there may be fracture in the arch of the superior vertebra. If a normal relation exists between the spinous processes of the fractured vertebra and the next superior vertebra but the spinous process of the second superior vertebra is separated by flexion, there must be fracture in the arch of the middle vertebra with anterior displacement of the body even though the fracture cannot be seen.

A somewhat similar situation is seen in spondylolisthesis although the lesion is developmental rather than traumatic. The spinous process of the fifth lumbar vertebra maintains normal relation with the sacrum (except that this process is underdeveloped) while the spinous process of the fourth lumbar vertebra is displaced forward accompanying its body and the body of the fifth lumbar vertebra.

*Dislocation.* Dislocation of a vertebra is usually accompanied by fracture as discussed under fracture dislocations. Dislocation without fracture is usually an anterior dislocation of a vertebra on the next inferior vertebra. It requires that the inferior facets of the superior vertebra shall have ridden upward and forward over the superior facets of the inferior vertebra. Oblique views may aid in demonstrating that the facets of the superior vertebra rest anterior to those of the inferior vertebra. This position of the facets encroaches visibly upon the space occupied by the nerve roots and may bring the posterior superior angle of the inferior vertebra in abnormally close relation with the laminae of the superior vertebra with consequent

pressure upon the spinal cord. Also, the position may cause locking of the facets, preventing reduction of the dislocation.

The arch of the dislocated vertebra being intact, the tip of the spinous process is displaced anteriorly in relation to the spine of the inferior vertebra.

Developmental spondylolisthesis differs from these features. The facets do not override and the spinous process does not move forward with the displaced vertebral body. Also, the arch of the affected vertebra is usually underdeveloped.

At the sacrococcygeal joint there are neither facets nor spinous processes. Severe angulation between the sacrum and coccyx is frequently developmental so angulation alone is insufficient evidence of dislocation. There must be abnormality of the space occupied by the sacrococcygeal intervertebral disk with the space much wider posteriorly than anteriorly or the anterior surfaces of the coccyx and sacrum must be out of line. Displacement of the coccyx is usually anteriorly but may be posteriorly. Lateral displacement is very rare.

Anterior subluxation of a vertebra, particularly a lumbar vertebra, occurs without fracture or dislocation in chronic arthritis. It is not common in industrial practice because the age group involved is older. Thinning of cartilage and other arthritic changes at the facets allow forward slipping of the vertebral body up to about  $\frac{3}{8}$  inch. The vertebra being intact, the spinous process moves forward equally with the body in relation to the inferior vertebra. There is no overriding of the facets. Cartilage is visibly thinned at the facets and intervertebral disk and there are irregular arthritic calcareous deposits about each of these sites.

Rotary subluxation is said to occur in the mid-cervical area. Such cases may represent merely a combination of a strain and a protective posture. To be classed as a subluxation, the vertebral posture should not be attainable within the range of motion of a normal spine. Such a degree of displace-

ment does not seem to be clearly demonstrated in these mid-cervical cases.

Rotary subluxation or dislocation of the first on the second cervical vertebra is usually spontaneous following inflammation in the throat. It is most common in children but may occur in young employed adults. The characteristic roentgen feature of this condition is seen in a view through the open mouth with the chin directly forward and the sagittal plane of the head perpendicular to the film. In this position, the spinous process of the second cervical vertebra, the center of the body of the same vertebra and the point of the chin are normally all in the midline of the cervical spine. In the rotary subluxation, the spinous process of the second cervical vertebra appears out of line to one side of the midline and the center of the body of the same vertebra is out of line to the other side, the side on which the rotary displacement of the first cervical vertebra is anterior.

*Reduced Fractures.* Reduction of the deformity of compression fracture of a vertebra by hyperextension results in an alteration of shape of the compressed vertebral body which is optimistically regarded as restoration of normal form. As a matter of fact, the deformity in the posterior and the inferior three-fifths of the vertebral body is essentially unchanged. The result of the hyperextension is simply that the fragment at the anterior superior angle of the affected body is pulled upward separating it from the inferior portion. This leaves a fairly extensive space between the fragments which must become filled with strong callus if the position is to be permanently maintained. The callus seldom becomes strong enough soon enough and much of the apparent correction is usually lost. In any case, the actual permanent improvement of deformity achieved by hyperextension cannot be determined until many months after all support has been removed from the spine.

Some of the sources of error in estimating

the amount of correction of deformity obtained by hyperextension are: Failure to observe the condition of the posterior portion and superior surface of the vertebral body; failure to allow for magnification of the vertebral shadows under the conditions of examination in hyperextension (if the height of the vertebra anteriorly is only 60 per cent of the height posteriorly the vertebra is still compressed 40 per cent no matter how much bigger it appears); failure to allow for difference of centering at different examinations (reliable conclusions are drawn only from similar examinations) and failure to follow the case a sufficient length of time to establish the permanent result.

*United Fractures.* The deformity of compression fracture, previously described, remains characteristic after healing and serves to distinguish the residual of previous fracture from other conditions. This is still true even though correction by hyperextension has been attempted; deformity of the superior surface remains characteristic.

Development of visible exuberant callus in three to eight weeks confirms the diagnosis of recent fracture, establishes the diagnosis of fracture which was previously doubtful or indicates the site of fracture which was previously invisible. Roentgen observation should be continued in doubtful cases for these reasons.

Ankylosis of vertebrae may occur at a fracture or dislocation. The calcification begins to develop in one to three months. If such calcification has not begun within that time, it cannot be expected to become sufficiently strong to ankylose the vertebrae firmly. When ankylosis is thought to be essential for stabilization following reduction of fracture or dislocation, delay in the appearance of the calcification suggests the necessity to look for some other means of stabilization such as surgical fusion.

Judgment of strength of union at a fracture (or surgical fusion) in the spine is a very difficult matter. The most important factor is experience. Of the visible factors,

the most reliable are increasing density of exuberant callus seen tangentially, decreasing sharpness of definition of the surfaces of fragments and increasing calcareous density in the spaces between fragments. When these changes have progressed to a marked degree the union is probably as strong as it will ever be until toughened by free use. An additional difficulty arises in the matter of callus occupying a space which is subject to weight thrust, such as the space between fragments at a compression fracture after correction by hyperextension. In such spaces the callus probably rarely becomes sufficiently strong to meet the weight thrust until it is toughened by use. One must, therefore, always be prepared to see some loss of correction on beginning unsupported function no matter how long support has been maintained.

A consideration which is particularly useful in judging the presence of union in surgical fusion is the fact that all corresponding parts of the fusion tend to act in the same manner if union is developing properly. The presence of an area which is not doing as well as the rest of the fusion in the matter of decreasing sharpness of definition and increasing density between fragments is strong evidence of the probable presence of pseudoarthrosis.

#### INVISIBLE TRAUMATIC LESIONS

It has been mentioned that there are many fractures in the spine which are not visible in the roentgen film and that some of them may be recognized in later examinations by reason of development of callus or of resorption along the fracture line while others remain forever invisible. There are several other conditions which are not directly visualised but, nevertheless, deserve roentgenologic discussion.

*Protrusion of an Intervertebral Disk.* Posterior protrusion of an intervertebral disk into the neural canal is not directly visible in the roentgen film but it may be outlined by injecting opaque material into the neural canal and causing it to flow up or down the canal by tilting the patient. The

technic is too well known to require discussion here. It suffices to say that the opaque material which gives the most clearly defined visualization is lipiodol; that the prone and oblique prone positions are most apt to demonstrate the defect; that the probable presence of posterior protrusion of an intervertebral disk is indicated when the lipiodol, under fluoroscopic control, cannot be made to enter a rounded area on one or both sides of the neural canal at or just above the level of an intervertebral disk; and that the lipiodol should be removed by aspiration at the end of the examination.

The posterior protrusion of an intervertebral disk is often identified in the lumbar region but doubtless exists much more often than it is even suspected in the cervical area. It is rare in the dorsal spine. Its presence may be suggested by thinning of an intervertebral disk, but actually there is little relation between thinning of a disk and its posterior protrusion.

The roentgen appearance of Schmorl's nodes is more or less well known. There is an area in the superior or inferior surface of a vertebral body, usually just anterior to its middle, at which bone does not extend so far peripherally as it does in the remainder of the body; there is a defect, or absence of bone, adjacent to the disk. The sides of the defect may be vertical rather than slanted and the floor of the defect tends to be flat rather than rounded. Such a defect is a developmental failure of bone formation, not a traumatic protrusion of the intervertebral disk into the vertebral body.

On the other hand, there are some cases in which a Schmorl's node is present when there is also thinning of the intervertebral disk and, in that very area, stiffness of the spine and ache or pain on motion or standing. Symptoms can be completely eliminated in these cases by surgical fusion of the two vertebrae adjacent to the thin disk. These cases suggest the possibility that injury has caused traumatic protrusion of the disk through the weak area at the

developmental defect (Schmorl's node) into the vertebral body with accompanying thinning of the intervertebral disk.

Protrusion of an intervertebral disk into the vertebral body also occurs with compression fracture but the protrusion is not visualized in the roentgen film and it is, at most, only a minor incident in the fracture.

**Contusion.** Contusions of the exposed portions of the spine are usually evident clinically and are invisible in the roentgenogram. They do not concern the roentgenologist except for the demonstration of the absence of visible fracture. Contusions may also occur indirectly by impact of bone on bone or intervening tissue. Some of these contusions have roentgenologic aspects.

Contusion of spinous processes by extension occurs especially in the lumbar area. The spinous processes are often so developed that there is little space between them. Sudden extension of such a spine may cause contusion of the tissue between the spinous processes with pain and tenderness localized at the point of injury. The contusion cannot be visualized but the close relation of spinous processes which predisposes to contusion can be demonstrated and visible fracture can be eliminated. A typical injury for the production of such a contusion is hyperextension at the moment of impact on the water in diving.

Many years ago a popular explanation for aseptic necrosis in various parts of the body was that contusion of the bone could cause petechial hemorrhages within it which led to bone resorption. This is certainly not the usual cause of aseptic necrosis; it may never be the cause and yet the possibility often requires consideration. When flexion injury of a spine is soon followed by variations in density within a vertebral body, some wedging and later repair the cause of the condition will probably be found among such diseases as osteomyelitis, tumor, hemangiomatous vertebra, xanthoma or postmenopausal osteoporosis. If no causative disease could be identified, the possibility of contusion

of the vertebra with subsequent aseptic necrosis might have to be considered.

**Strain.** The roentgen film does not visualize strain directly but it may demonstrate a protective posture which, in the absence of a visible lesion, suggests or even indicates strain. A persistent deviation of the spine without structural cause is usually a protective posture. This is particularly true for lateral and rotary deviations in the cervical spine and, in the lumbar spine, for decreased lordosis and lateral deviation. In the lumbar area, decrease of lordosis when standing as compared to the lordosis when lying in an habitual posture is definitely a protective reaction indicating that lumbosacral strain is present.

The roentgenogram also demonstrates the presence of structural variations which predispose to strain. Deviation of vertebrae as in scoliosis and weakness of joint tissues as in arthritis reduce the reserve of strength available to meet extraneous impacts and hence predispose to strain which may occur with apparently trivial injury. The lumbosacral area is a prolific source of mechanical weaknesses which predispose to lumbosacral strain.

Industry may make more use of the demonstration of these mechanical weaknesses than it has done in the past. The affected employee can be protected against strain. He should not be required to make some effort involving the affected area which is far beyond the effort to which he has been accustomed in the previous few days. After a long lay-off he should not return suddenly to full labor but should make increasing effort covering several days.

Anomalies which predispose to lumbosacral strain include transitional vertebrae, spondylolysis, posterior prominence of the fifth lumbar vertebra and several other variations. They all have in common one or both of two elements of mechanical weakness, unstable facets or unstable lumbosacral angle.

The stable lumbosacral facets are those

which are well formed and face each other from side to side (the internal-external type). Instability arises when the facets are large, abnormally small, inclined laterally, asymmetrical or fail to face each other from side to side (the oblique and anteroposterior types). Marked asymmetry of the facets regularly results in strains beginning in the third decade of life.

The plane of the facets at the lumbosacral joint is easily judged in the anteroposterior view. If the lumbar facet completely overlaps the width of the sacral facet, the joint is the anteroposterior type; if the area of overlap of the facets is less than one-quarter of the total width of the facet shadows, the joint is the internal-external type. Various degrees of obliquity are indicated by degrees of overlapping intermediate between these two extremes. Fifty per cent overlapping corresponds to about 40 degrees of obliquity of the joint.

The stable lumbosacral angle is one in which the inclination of the superior surface of the sacrum to the horizontal in the habitual posture of the patient is not over 42 degrees; also, the center of gravity of the trunk as represented by a vertical line through the center of the body of the third lumbar vertebra passes not more than  $\frac{1}{2}$  inch in front of the sacrum. Instability arises when the inclination of the sacral surface to the horizontal is more than 42 degrees or the center of gravity of the trunk is more than  $\frac{1}{2}$  inch in front of the sacrum. Severe instability is present when the lumbosacral angle is as much as 52 degrees or the line of weight thrust is as much as  $1\frac{1}{2}$  inches in front of the sacrum.

These relationships are easily judged in a true lateral view of the lumbosacral area with the patient in his habitual posture. Unless the examination is carelessly done the bottom of the film represents the horizontal from which the inclination of the sacral surface can be measured and a line perpendicular to the bottom of the film drawn through the center of the shadow of the body of the third lumbar vertebra represents the line of weight thrust and its

relation to the anterior superior angle of the sacrum.

#### POST-TRAUMATIC CONDITIONS

*Progressive Wedging of a Vertebral Body.* Wedging after injury is practically never progressive in a vertebra which was previously healthy. If it does occur, it is slight. Progressive post-traumatic wedging should suggest disease. The condition usually present is postmenopausal osteoporosis with spontaneous collapse of the vertebrae. In this condition the vertebrae are undercalcified and wedged anteriorly with concavity of the superior and inferior surfaces and corresponding tendency of the intervertebral disc to be of spherical shape. Several vertebrae are wedged or soon become so.

Radiation of the neck stops the progress of wedging and relieves the symptoms of dull ache, weakness and fatigue in the back in this condition although some of the sharp pains on motion (due to accompanying osteoarthritis) may persist. This has been the result in each of ninety patients treated by the author. The right, left and posterior aspects of the neck in the parathyroid area are exposed to 150 to 200 r successively at intervals of three or four days. The series of three treatments is repeated at three-week intervals if symptoms are still prominent. Three or four series should suffice for relief of the patient.

*Static Strain Due to Deformity.* Just as developmental deformities causing mechanical weakness or instability may predispose to strain, so also may deformities resulting from dislocation or compression fracture. Kyphos establishes a weak structure which may result in strain. The predisposition to strain may be present not only at the kyphos but also at the lumbosacral area the posture of which is altered to compensate for kyphos in the low dorsal or lumbar area. In fact, the lumbosacral strain is apt to be the more troublesome to the patient and this area should be examined for instability in the manner that has been described.

*Chronic Strain.* When strain has occurred at an area (usually the lumbosacral area or a kyphos) where unstable structure predisposed to strain the patient may have difficulty recovering from the injury. Persistence or frequent recurrence of strain may then establish a chronic strain. The strain itself is, of course, not visible in the roentgen film but the predisposing unstable structure is demonstrable and should be studied and judged as has been described.

Where chronic strain persists for a sufficient length of time degenerative changes are apt to occur and become recognizable as post-traumatic arthritis.

*Post-traumatic Arthritis.* Degenerative arthritis is indicated in the spine by lipping or spur formation at the vertebral margins with or without some thinning of cartilage at the facets or intervertebral disks. When the arthritis is evident only at one joint or area it is reasonable to conclude that the arthritis is post-traumatic. (Fig. 3.) When such a joint is subject to prolonged vibratory forces, as in riding on a train or truck, spasm about the joint may become very extensive and a very stiff painful back may result. That is the so-called "railroad spine."

#### ROENTGEN DEMONSTRATION OF VERTEBRAL ABNORMALITIES

The examination for the roentgen features which have been described should be based upon true anteroposterior and lateral views of the various regions of the spine. If the condition is not clearly determined by this examination, oblique and stereoscopic views may be added. For the first cervical vertebra a view through the open mouth is usually essential and for the lumbosacral joint a view which is anteroposterior oblique from below upward is helpful.

Routine views should ordinarily be taken in the supine positions but the erect position is often better for demonstration of protective postures, especially in the lum-



bosacral area. Estimation of the lumbosacral angle is best made in the supine position for the reason that, on standing, the pelvis normally tilts forward, increasing the lumbosacral angle, but when lumbosacral strain is present the pelvis tilts backward in a protective posture. Thus, the unstable lumbosacral angle which has led to strain may appear more stable when examined in the erect position. Obviously, examination in both positions can be used to determine that this protective reaction occurs and that lumbosacral strain is, therefore, actually present. This may be particularly useful when malingering is suspected.

Solidity of ankylosis or surgical fusion

may be tested by examination antero-posteriorly or laterally in bent positions. Bending to the limit of motion in each of two opposite directions should reveal motion at the joint in question if ankylosis is not solid.

Laminography may be used for the demonstration of conditions at a particular plane within the vertebrae but this type of examination merely presents in a different manner the lesions or conditions which an able interpreter should see on the ordinary type films.

Injection of opaque material (or of air) into the neural canal is used for the demonstration of posterior protrusion of an intervertebral disk as has been discussed.





# BACK INJURIES IN INDUSTRY

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FROM the records of the Industrial Accident Board of Massachusetts for 1944, there were 8,547 reported and contested back injuries. We believe these represent a fair cross-section of the United States as a whole and emphasize the importance of back injuries in industry, both in regard to lost time and lost wages, as well as the loss of production incident to such injuries. One must realize further that these statistics represent only a small proportion of back injuries, since only contested cases appear before the Industrial Accident Board. These figures emphasize the dire need of better diagnosis and treatment in relation to back injuries on the part of the medical profession as a whole.

It is evident that as orthopedic specialists we have failed to solve the enigma of the "industrial back." This may be due in part to the fact that so much consideration has been given to the theoretical side of back injuries and so little attention has been directed to the practical side. All the facts are present; it is our interpretation which is faulty and at times illogical. The orthopedist should make his diagnosis on the basis of positive findings only and not by a process of elimination or from theoretical considerations. In view of these facts we are in no position to criticize the average general practitioner of medicine for his treatment of all back injuries with adhesive strapping. We ourselves have failed to solve the problem of diagnosis and treatment of back injuries and therefore have been unable to give the general practitioner the help which he so justly and urgently needs.

## ANATOMICAL CONSIDERATIONS

Under this heading one must consider the general build and musculature of the individual as a whole. There are many different anatomic types but, in general, we may

say they are divided into the short, stocky, heavily-muscled type and the long, thin, small-boned, lightly-muscled individual. It is obvious that the former has a distinct mechanical advantage, of the lever and fulcrum variety, in doing heavy laborious work, and, as a result, is less prone to develop back injuries. These facts are of particular importance when one realizes that the muscles are the most important structures and the primary defense against bone, joint and ligamentous injuries.

Developmental anomalies are often considered to predispose to back injury. Among these are incomplete fusion of the sacrum, asymmetrical facets in the low lumbar spine of the inferior type, mechanically, increased lumbosacral angle with forward tilting of the pelvis, pre-spondylolithesis and other congenital conditions resulting in the so-called unstable back. While we believe these conditions may predispose to back injury in certain individuals, there is no question that many individuals showing such types of so-called structurally weak backs, have no symptoms whatsoever under the most severe and heavy working conditions. One must, therefore, not be too positive in one's statement in regard to this group of cases.

## PRE-OCCUPATIONAL EXAMINATIONS

From an industrial point of view all patients who are to be employed on specific types of industrial work warrant careful physical examination, both as to their general condition and as to their ability to perform heavy manual labor. Pre-occupational examinations by adequately trained medical men would do a great deal to alleviate most of the present troubles in relation to back injuries and disease. All individuals seeking employment in laborious work should be free from general disease, particularly diseases of the heart,

lungs and vascular system. A careful check-up should be made for systemic diseases, such as diabetes, nephritis, gastric ulcer and anemias. In simple language, pre-occupational examinations are definitely indicated, both for the protection of the employee as well as the employer. We do not believe that discrimination should be made against individuals because of the underlying disease, but we do believe they should be placed in jobs which they are physically able to do and adapted to their physical abilities for employment.

#### HISTORY AND PHYSICAL EXAMINATION

*History.* The history is of paramount importance in back injuries. This should include a careful consideration of the past history of the individual in relation to injuries, illnesses, diseases or operations, as these may have some important bearing on the present illness.

In respect to the present illness, one must carefully consider all the details in relation to the accident. One should endeavor to give an exact description so that one may visualize the actual mechanics involved: the position of the patient, the direction of the weight lifted as well as the amount, the extent of the muscular effort involved, the type of pain, including its character, distribution and precise location, and whether or not radiation of the pain occurred at the time of the injury or developed later. It is important to note whether the patient could continue working, or whether the patient worked some time and then had to stop on account of pain. One must then consider how the patient obtained relief from pain, whether by sitting, standing or lying down. The exact type of treatment given at the time of the accident and subsequent to the accident should be carefully listed. Proper evaluation should be given to the first medical examination. Previous attacks of back pain of any character should be noted.

Pain localized in the back which increases as the day goes on in direct ratio to the

time the patient is on his feet and the amount of work which he performed is apt to be mechanical in origin. A pain which is severe when the patient arises in the morning and lessens as the activity of the day goes on is apt to be systemic in origin. Localized pain, non-radiating in character, with the history of a severe muscular effort in lifting, is almost always a simple muscle strain. Radiation pain down the leg or legs should be carefully localized by the examining physician and an accurate determination of its distribution should be made by plotting the sensory distribution. Such sciatic pain can usually be attributed to sacral 1 or 2, or sacral 1, lumbar 5 or lumbar 4, 5 sacral 1.

*Physical Examination.* First and of the utmost importance all patients presenting themselves for examination of the back or complaints referable to the back should be completely undressed, including shoes and stockings. The general posture of the individual should first be noted. This should include proper evaluation of the spinal curves, whether the head and shoulders are forward, whether the dorsal curve is increased or lumbar lordosis increased, or pelvis tilted forward, also whether the abdomen is relaxed. What is the state of the general musculature of the individual as a whole? Are the lower extremities symmetrical and straight? Do bow legs, knock knees, flat feet or any degree of pronation of the feet exist? Such an evaluation should be included in the first statement of the individual as a whole.

Along with this there should be a careful general physical examination to determine whether or not there may be a focus of infection in the nose and throat, the presence or absence of abscessed teeth the presence of cavities, gingivitis, pyorrhea, inflamed or chronically diseased tonsils, blood and pulse pressure, heart rate—all these should be noted. One should also check the lungs for any gross pathologic condition and examine the abdomen for any abnormal masses, spasm or tenderness. A rectal examination should also be done to



FIG. 1. Typical example of list; trunk shifted on plevus. Patient flexed forward at waist and right knee flexed.



FIG. 2. Forward bending; patient goes toward affected side, does not reverse lumbar spine and flexes right knee at the limit of forward flexion.

determine whether or not the prostate and rectum are normal.

After such a preliminary examination to determine the general condition of the individual from a physical point of view, our attention is then directed to the detailed examination of the back.

#### EXAMINATION OF THE BACK

*Standing Position.* The first position described is the standing position. In this, one notes whether or not there is a scoliosis present, and if so, whether this is of the functional or structural type. The functional type is usually due to a postural condition, often a short leg, and is of long-standing, usually developmental in origin. The structural type may be of any degree but if the curvature is of a severe type it is always accompanied by gross deformity of the ribs and a double structural curve. The

type most often seen in back injuries is the so-called sciatic scoliosis which is accompanied by a very definite list. (Figs. 1 and 2.) This may be classified as protective in nature and caused by acute muscle spasm. It is well for the examiner to sit behind the patient on a chair or stool and carefully note the presence or absence of such a list: asymmetry of the hips, inequality in the height of the shoulders or other abnormality in relation to the spinal curves. A list of the trunk to the right or left with a tendency to flex the knee on the affected side in which radiation pain exists down the leg, indicates a deep seated lesion classified as low back disorders which include lumbosacral, sacro-iliac or intervertebral disc injuries. The patient is first asked to flex the body forward, relaxing the arms and keeping the knees perfectly straight or extended as much as possible. Normally, a

reversal of the lumbar spine occurs from a concave to a convex curve and indicates normal muscular action and normal segmentation of the vertebrae involved. If such forward bending, as is described above, is possible and complete reversal of the lumbar spine occurs, the presence of reflex muscular spasm can be definitely eliminated, whether this be from arthritis, nerve root compression, or some other type of deep seated injury. Following a reversal of the lumbar curve, forward tilting of the pelvis occurs on the trunk. This is accomplished by the iliopsoas muscles plus gravity. If deep seated injury or pathologic condition prevents this motion, i.e., normal reversal of the lumbar curve, the hamstrings do not relax, since they are the opposing group to the iliopsoas. In such a case the only manner by which the patient may fully flex the back or tilt the pelvis is by relaxation of the hamstring muscles by flexing the knees. To recapitulate, any patient who is able to stand without a list or without asymmetry, who is able to reverse the lumbar curve, tilt the pelvis with the knees straight touching the floor with his hands, come back to the erect position without discomfort or muscle spasm, may be eliminated from the possibility of any deep seated back injury. Next, lateral motions are performed to determine whether the curves of the spine are symmetrical and whether the motions in these directions are restricted by muscle spasm. Such limitation, if present, is carefully noted and accurately described as to degree and as to the point where pain is first noted. Hyperextension of the spine is then tested; the amount of motion present is determined and the point and location of pain carefully noted, if this exists, on extremes of motion. Rotation of the spine is also carefully checked and the presence or absence of limitation and pain recorded.

*Lying or Recumbent Position.* The patient is placed in recumbency on a well padded examining table and allowed to relax in a comfortable position before the examination proceeds further. Knee jerks

and ankle jerks are tested. The lower extremities are then examined. The muscle tone of the legs is determined by palpation of the muscles and the presence or absence of deep muscle tenderness is noted. Any areas of disturbed sensation are also carefully noted as well as circulation in the extremities and motor function. The presence or absence of muscle atrophy is recorded and the calves and thighs are measured at corresponding points. Such measurements, to be accurate, must be taken from a fixed point. One ordinarily measures from the top of the patella to a point 6 inches up the thigh where a mark is made and the corresponding measurements recorded. On the calf, one ordinarily measures from the tibial tubercle to the maximum circumference of the calf. In any condition in which severe pain exists and there is nerve root pressure, atrophy of the quadriceps group quickly occurs from disuse and reflex irritation. Straight leg raising is then determined and is an extremely valuable test. The patient is asked to lift the leg with the knee fully extended. Both active and passive straight leg raising is usually done. Considering the recumbent position zero degrees, straight leg raising to 70 or 80 degrees or just short of a right angle is normally present, although a certain degree of individual variation exists. The value of this test lies in the fact that there is compensatory relationship in motion between the lumbar spine and the hip joint. Briefly stated, it is impossible for a person to raise the leg with the knee fully extended unless the lumbar spine is flat and free from muscle spasm. Conversely it is true that if a patient has a lumbar spine in spasm with limitation of motion, he is unable to lift the leg straight from the table with the knee extended without limitation of motion.

The patient is then examined face down. The tips of all the spinous processes are palpated by direct pressure. Exact points of tenderness are noted, particularly the point of maximum tenderness. If a lumbosacral strain exists, the pain is referred to the lumbosacral angle; if a sacro-iliac strain,

the pain is referred to the sacro-iliac joint and the superior and inferior sacro-iliac ligaments may be tender. In cases of simple muscle strain the erector spinae insertion or the muscle bellies themselves may be acutely tender. By feeling lateral to the erector spinae group, the quadratus lumborum muscle may be palpated by considerable pressure of the examining finger. The posterior iliac crests and the posterior spine of the ilium may be palpated, also the sciatic notch. The lumbar fascia and gluteal bursa should be carefully checked for the presence or absence of point tenderness. The sciatic notch and nerve and deep muscle tenderness are also recorded. Hyperextension of both hips is then attempted and the presence or absence of tenderness or muscle spasm noted. It is also possible in this position with the knees flexed and extended both to determine rotation of the hips, the presence or absence of muscle spasm and also abduction and adduction of the hips. This position is also favorable for determining ankle jerks, since it is easier for the patient to relax.

*Sitting Position.* A sitting test is now carried out. With the patient lying prone on the table, the examiner's arm is thrown across or above the knees, and without flexion the patient is asked to sit upright on the table. The normal individual should be able to go beyond a right angle without any discomfort. In deep seated conditions of the back and spine there is definite limitation of forward bending with superimposed body weight, and one finds that in a recumbent position the patient cannot come to within several degrees of a right angle and complains of pain and discomfort in the low back. This, of course, is due to the presence of spasm in the hamstrings, which prevents flexion of the pelvis on the trunk. (Many cases of the so-called malingering type may be detected by this test. These individuals often refuse to bend forward in the standing position more than a few degrees, but in this particular test in the recumbent position they will come to an upright position well forward

of a right angle while sitting with the knees extended, which definitely marks them as malingerers.)

The mechanics of the feet should be carefully evaluated as they may be contributory factors in many persistent backaches. The predominant symptoms in pronated feet are fatigue, tiredness and discomfort in the back, increased in direct relation to the amount the patient is on his feet. Such cases may often be further complicated by peroneal spasm, pain and discomfort over the peroneal muscles. On examination, there is a good deal of tenderness in the pronated foot, both over the longitudinal and transverse arches, and at times short or tight heel cords may also be a factor. The presence or absence of bunions, callosities, circulatory disturbances, etc., should all be noted and properly evaluated, as they may be factors in low back pain.

We believe that the simplest way to consider the whole problem of the back is to evaluate the individual's general health, his past history and present illness, and then consider the back injury from a diagnostic point of view. Once the diagnosis has been established, treatment becomes relatively simple.

#### SIMPLE BACK STRAIN

The simplest type of back injury, we believe, is back strain or sprain. This condition usually occurs in an individual attempting to lift too great a weight, often under mechanical disadvantage or faulty body mechanics, or the lifting of moderate weights over a period of time under similar conditions. In such instances, the patient usually has great difficulty in straightening up or coming to the erect position. The pain is usually in the low back opposite the lumbosacral junction, or what we term the small of the back, or somewhere in the lumbar region. The pain, as a rule, is dull and aching in character and non-radiating in type. On physical examination (patient stripped) there is localized tenderness over the injured area, often at the erector spinae insertion into the sacrum. The tenderness

may extend to the lumbosacral junction. The lumbar muscles are obviously in spasm and any attempt at forward bending, hyperextension, lateral bending or rotation is checked by acute muscle spasm; if motions are forced, the patient complains of pain in the low back. As a general rule, symptoms usually develop several hours after the individual's muscular effort and are due to muscle spasm. Frequently, they do not appear until the following day when the patient attempts to get out of bed. These patients are suffering from acute muscle strain and the treatment is relatively simple. Such cases respond to local heat, particularly in the form of moist, wet heat employed by hot Turkish or bath towels or a hot pad. In our opinion, the back should not be strapped. Adhesive strapping is inefficient and does not actually immobilize the back in any sense. If the patient is so incapacitated that he is unable to pursue his occupation, rest in bed with some counterirritant as heat is without question the proper treatment. Massage is often of inestimable value and is particularly beneficial when most of the muscle spasm has disappeared. In some instances, simply hitting the low back muscles, i.e., lumbar muscles, with the flat of the hand or by ironing the muscles with the application of towels to protect the skin, may afford relief. At times such relief is spectacular. In cases of simple back strain, disability should not exceed five to ten days. This is the simplest form of back injury and presents no particular problem.

#### DEEP SEATED BACK STRAIN

Next one must consider deep seated low back strain, and this we believe to be the most common of all back injuries. This is a deep seated and complicated type of injury and not to be confused with simple back strain. Often there is an underlying background of either a posturally weak back, the presence of hypertrophic arthritis, or degenerative age changes, and in addition there is frequently history of repeated back injuries. Such cases usually give a history

of dull aching pain at the lumbosacral junction, which, characteristically, does not radiate down the leg but may radiate down the thigh as far as the greater trochanter or slightly below. The maximum pain and discomfort is over the lumbosacral junction with complaint of dull aching pain in this region, usually increased by occupation, particularly if it entails a good deal of standing, stooping or lying. Such cases deserve a careful examination of the feet, consideration of their general posture, and usually represent a combination of mechanical and muscular difficulties. If the feet are pronated, this condition should be connected by proper support of the arch at the inner border of the foot. Bow leg or knock knee should be adequately treated. Increased lordosis is usually an indication of faulty body mechanics and most often it is a combination of this and relaxed musculature. Such cases require supportive treatment both in relation to the feet, lower extremities, lumbosacral junction, and in addition the general musculature of the individual should be toned up. We believe that the increased lumbosacral angle can best be treated in the initial phases by proper supportive treatment with a rigid type of back support. Such a rigid brace, properly fitted, will give definite relief of symptoms referable to the lumbosacral region. We do not believe that this should be permanent in any sense and as soon as the patient has obtained relief from symptoms over a sufficient period of time, active exercises should be instituted to improve the musculature of the back and abdomen. This, together with proper postural training, should enable the individual to eliminate the use of the brace. Such cases usually improve fairly rapidly under this regimen. There is often a decided tendency by both doctor and patient to prolong the use of braces and supports unnecessarily.

*Sacro-iliac Strain.* It is the belief of both authors that this condition, as an entity, rarely exists other than incidental to the relaxation that occurs in preg-

nancy or actual disease of the sacro-iliac articulation.

The authors have further noted that in true cases of traumatic evulsion of the sacro-iliac joint in which the entire half of the pelvis was displaced upward about  $\frac{3}{4}$  inch, the chief complaints were referable to the anterior aspect of the thigh along the distribution of the femoral nerve rather than the sciatic nerve. However, we believe that reflex irritation of the sciatic nerve may occasionally be encountered although this is not characteristic. Where actual disease of the sacro-iliac joint exists, fusion or immobilization is definitely indicated.

We must now consider a much larger group of cases in which the complaints and the pathologic conditions are much more deeply seated and more difficult of diagnosis. This is a group of cases accompanied by radiation pain, many of which show sciatic scoliosis. These cases are very difficult to evaluate and diagnose. Many show a list, limited forward and lateral bending, rotation, limitation of straight leg raising, positive sitting test and often diminished ankle jerks. In many instances x-rays may be negative. There is no doubt that a certain small proportion of these cases may represent rupture of the intervertebral disc. Specifically, such cases show radiation pain down the outer side of the thigh, lower leg and outer side of the foot over the sensory distribution of first and second sacral nerves. They also show tenderness over the sciatic nerve and deep muscle tenderness; oftentimes they have spasm and atrophy of the affected muscles of the extremities and occasionally muscle weakness to a noticeable degree. The ankle jerk on the affected side is often diminished or lost and not infrequently there is disturbance of the sphincters, either bladder or rectum. Pain is a very characteristic symptom and often may be severe in quality, so that the patient is unable to sleep without sedation. It is our belief that this group of cases, even though a rupture of the intervertebral disc may be suspected, all types of

conservative treatment for relief of the symptoms should be thoroughly tried before the patient is hospitalized for intervertebral disc surgery or investigation. In the first place, such cases often respond to simple back treatment. Such cases should be put on fracture boards with no privileges, to remain absolutely quiet in bed for a period of ten days to two weeks, and should have local heat, massage and supportive treatment. In many instances, the symptoms will clear up without further treatment. If muscle spasms still persists at the end of ten days, we believe that traction of the affected extremity should also be tried. Oftentimes, relief may be obtained by the injection of novocaine and saline into the so-called local or trigger points of tenderness. If the patient does not respond to such treatment, manipulation of the back is definitely indicated. This, of course, requires hospitalization and the general condition of the individual as an operative risk should first be carefully evaluated.

#### TECHNIC OF MANIPULATION

The gastrointestinal tract is completely cleansed with enemas or mild cathartics. The affected leg is shaved. This is all done on the night prior to manipulation. Under general anesthesia, the patient lies relaxed back down on the table. An assistant then supports the opposite side of the pelvis and the manipulator, with the patient's leg fully extended at the knee, stretches the hamstrings. In performing this act, the operator carries the leg well beyond a right angle in his first stretching, then brings it back to the horizontal position. Each time he stretches he goes a bit further in his manipulation. In some instances, one stretches the leg almost to the point of putting the foot on the forehead. A complication which has occurred a few times in over 300 cases is that the head of the femur slips over the posterior lip of the acetabulum (which is startling to say the least) but it replaces itself very rapidly when the leg is brought straight again. When the



hamstrings are considered thoroughly stretched, the patient is turned over on his face, with a pillow placed under the chest to improve the breathing. The operator then places his right arm under the patient's thighs and lifts the legs and pelvis to hyperextend the spine. In a true low back strain, even with the patient anesthetized, one is not able to define a good lumbar curve of the spine until the pelvis is given a torsional twist. Here it may be stated that in a very small percentage of cases a definite click has been heard and a well defined lumbar concave curve results. The patient is then rolled on his back and 15 pounds of extension applied with adhesive moleskin. This should be done before the patient has come out of ether. The patient is then left with this extension on for a period of ten days to two weeks during which time he is not allowed to raise his head from the pillow. On the tenth to the fourteenth day the patient is relieved of the extension, allowed to roll around in bed for a day or two, and then get up on crutches for a week, using no support in the form of a brace or jacket on the back.

The post-manipulative convalescent period is sometimes attended with discomfort over the tuberosity of the ischium, which we suppose is due to the pull on the attachment of the hamstrings. The questionnaires returned from about 300 cases showed that about 75 per cent had had entire relief of discomfort in the back without any recurrence. We believe that the other 25 per cent fall into the class which should be investigated for possible intervertebral disc disorders.

There is a real possibility that in doing these manipulations we reduce a certain percentage of cases which have protrusion of a disc. This being true, why not manipulate and reduce any given case with a proven defect by myelography? This would eliminate at least temporarily the necessity for open operation.\*

\* A complication which has been noted in six to eight cases out of the series is an ileus appearing twenty-four

#### RUPTURED INTERVERTEBRAL DISC

We are of the opinion that on the whole the results from operations performed for ruptured intervertebral disc are appallingly bad. At the present time, the enthusiasm for this operation has gotten beyond the bounds of common sense and logic. Patients are often operated upon without adequate study and many times before any other type of treatment has been instituted. It is our opinion that many discs get well without operation as they did prior to the institution of operation for ruptured disc. Furthermore, operation should be performed only after all available methods of treatment have failed to give relief. When such a procedure must be done, we believe it should be done with the close cooperation of the neurosurgeon and the orthopedic surgeon.

One must now consider hospitalization of the patient who has failed to respond to all methods of conservative treatment for diagnosis of ruptured intervertebral disc. At this point, consultation between orthopedist and radiologist is most essential. A lumbar puncture should be done and a careful hydrodynamics of the spinal fluid should be carried out. This should include initial pressure, pressure with respiration, pulse, jugular compression (both single and bilateral), pressure after removal of 5 and 10 cc., and a chemical analysis of the spinal fluid, to include total protein, Hinton, and in certain cases, colloidal gold test. X-ray visualization of the spinal canal is also definitely indicated. At the present time, lipiodol or air visualization is seldom employed. (Figs. 3 and 4.) Pantopaque seems to be the opaque dye of choice, at least in the New England States. A positive test with a definition defect is very helpful in diagnosis and localization of the lesion. One must realize, however, that even in the

to forty-eight hours after the manipulation. This has occurred in cases in which there has been a history of chronic constipation in which there is not a pre-manipulative intestinal elimination. In one patient in whom acute dilatation of the stomach was a complication, it was necessary to introduce a Wangensteen tube.



Compression fractures of the vertebrae without neurological symptoms, or even with neurological symptoms, we believe should be treated by hyperextension, and, in our opinion, this is best done under an anesthetic when reduction may be im-

mediately accomplished, as is done with fractures of the long bones. This eliminates the pain and discomfort of gradual hyperextension and insures an adequate reduction. Such cases are put in hyperextension in a plaster cast and following this may be allowed to roll about in bed freely. No weight-bearing is allowed, however, in these cases for at least eight or nine weeks. At the end of this time, the plaster cast is removed and a rigid type of long back brace applied. This should be worn for an additional three to four months. At the end of this time, the brace is eliminated after the patient has developed his musculature to a sufficient degree. He may then return to work. Such fractures usually mean about six to eight months of disability, on occasion this may extend as long as one year.

Fractures of the transverse processes, in our opinion, are usually overtreated. We believe that these should not be immobilized in plaster but the patient put to rest in bed until muscle spasm disappears. Following this, he is gotten up and about and as soon as he feels physically able he may return to his work. In our opinion, it is of no significance whether or not these processes unite by x-ray, since most of the patients have no symptoms.

#### ARTHRITIS

The commonest type of arthritis encountered is the so-called hypertrophic arthritis which is seen in a large majority of individuals after the age of forty. We wish to call attention to the fact that this type of arthritis involving only the vertebral bodies, is degenerative in nature and not accompanied by symptoms. It is only when the articular facets between the vertebrae become involved in the process that symptoms occur. One should be careful in using the expression, arthritis, as applied to degenerative changes since many people have a horror of the crippling deformities incident to a degenerative arthritis, particularly of the deforming type. There is no doubt that many of these individuals have referred pain and in many

instances the intervertebral foramina may be distinctly narrowed. We believe that such individuals are prone to inflammatory changes, irritation of nerve root and symptoms of referred pain. In such cases, there is usually no history of a definite injury; they are doing their regular work when they suddenly have acute pain in the back and often radiation pain along the course of the sciatic nerve. A careful examination often reveals a focus of infection, particularly in the nose, throat or teeth. Correction of these underlying conditions will usually clear up the disability which is one of neuritis.

The four specific types of arthritis for which the etiology is known are tuberculosis, syphilis, gonorrhea and gout. In each case the condition is non-industrial and there is only the possibility of aggravation to be considered in relation to their occupation. In such instances, the aggravation factor can only exist for a reasonable length of time, which will depend somewhat upon their age and general condition. We believe that the ultimate course of disease is not influenced by trauma but symptoms of the injury may be prolonged.

#### EPIPHYSITIS

Epiphysitis of the spine is a more serious condition than is generally recognized by the medical profession. The centers of ossification are extremely active in young individuals between the ages of twelve and eighteen, particularly in relation to the vertebrae. (Figs. 5 and 6.) Certain industrial occupations which require bending over a long period of time may predispose to the rounded back so often seen in later life. A seemingly trivial injury may cause damage to these epiphyses. These individuals show the so-called rounded back and should not be employed industrially for any work which requires lifting, stooping or bending. Oftentimes, this condition seems to be hereditary and we have seen numerous examples in which the condition has been present in both the father, mother and

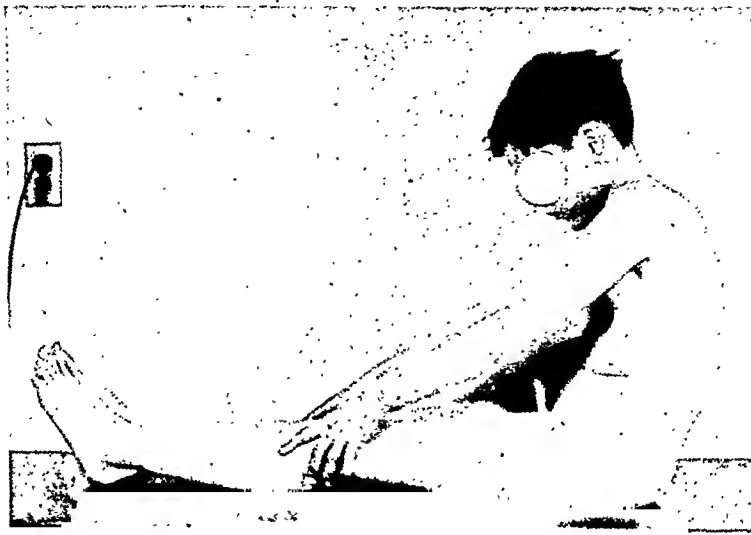


FIG. 5. Typical posture of a sitting test in a young boy with acute epiphysitis following injury.

children, and in some instances even in the grandparents.

#### SPONDYLOLISTHESIS IN RELATION TO BACK INJURY

It is our belief that this is usually congenital in origin and we have never seen a case of traumatic spondylolithesis of the lumbosacral junction which could be definitely proven to be entirely traumatic in origin except where fracture also occurred. We also believe that this condition is much more prevalent than is ordinarily recognized. In our experience, most patients begin to show symptoms as a result of advanced age with increase in body weight and subsequent change in body mechanics. Slipping is usually of a gradual degree and is not the result of any one specific accident. Therefore, in relation to industry there is only the question of aggravation to be considered and such aggravation we believe should be limited to a period of three to four months at the most. We do not think that sacralization of the transverse processes or impingement of the spinous processes, except possibly in rare instances, are the cause of back symptoms.

#### OSTEOPOROSIS

Osteoporosis or bone atrophy may at times be a complicating factor in back

injuries. It is often found in old age and occasionally in middle life. It is progressive in character, and, in our opinion, not aggravated by a specific trauma. It is usually associated with a glandular imbalance. Trauma may conceivably aggravate the underlying condition. It is difficult to state how long such an aggravation should reasonably exist and how much disability should reasonably be allowed. It is our belief that eight to twelve weeks is certainly a generous allowance, but this will vary with different individuals and different doctors.

#### INCONSISTENT SIGNS AND SYMPTOMS IN RELATION TO BACK INJURIES

It has been estimated that in from 10 to 20 per cent of all back injuries certain inconsistencies are found. A certain proportion of these fall into the group known as malingerers. Malingering may be defined as an attempt on the part of a patient wilfully to deceive the examining physician in relation to his signs and symptoms. Several methods of detecting such inconsistencies are noted:

1. In putting the patient through motions of the back in forward bending, we find many times that he refuses to flex forward at the hips, holds himself rigid, trembles all over and is sensitive no

matter where touched. This observation makes one suspicious. Our method has been to put this patient through the entire examination as previously described, leaving to the last the sitting test. The examiner then puts the patient through essentially the same mechanical motion without superimposed body weight, and in placing the arms across the knees, one finds the patient inadvertently going well beyond a right angle.

2. In observing the patient dressing and undressing, he will many times refuse to bend forward, and yet he will stoop over and pick up his trousers from the floor, pull them on over his feet and legs without the slightest difficulty.

3. Straight leg raising is another test. The patient here will refuse to raise the leg. The examiner carries the leg gently up and holds it to the full straight leg raising range, 70 to 90 degrees, and then asks the patient to hold it there. He does it without the slightest difficulty and is using exactly the same muscles and flattens out his lumbar spine in exactly the same manner as he would in normal straight leg raising.

#### SUMMARY

1. This is a plea for more careful examinations and proper interpretation of symptoms in the case of industrial back injuries.

2. Closer cooperation between orthopedist, neurosurgeon and radiologist is urged.

3. Less emphasis should be placed upon congenital malformations as expressed in the x-ray. Their importance should be properly evaluated in any given case and not overemphasized to the patient.

4. The surgeon should rationalize the entire subject of ruptured intervertebral disc disorders, and attempt to classify



FIG. 6. Forward bending markedly limited in a young boy with acute epiphysitis.

symptoms, evaluate myelography and curb the hyperenthusiasm of operative procedures which is sweeping the country at the present time.

5. He should eliminate the use of adhesive plaster as a universal treatment for acute conditions of the back and minimize the number of braces and jackets applied indiscriminately in injuries to back, as they only tend to produce muscle atrophy and prolong convalescence in a fair percentage of alleged back injuries.

6. It is our opinion that if the proper evaluation is given to the patient's history, physical findings, x-ray and laboratory findings, each individual may be diagnosed and treated on a scientific basis. If such measures are taken, much of the bugaboo which now confronts us in relation to back injuries will be eliminated.



# OPERATIVE INDICATIONS IN TRAUMA TO THE LOW BACK

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**L**OW back pain, post-traumatic and following disease, has always been and is one of the most common and confusing problems confronting the physician. A review of both conservative and operative methods that have enjoyed popularity at various times during the past forty years indicates almost total disunity of opinion of workers in this field.

It is our purpose in this brief paper to discuss the major indications for operative interference in certain conditions of the lower back. Even though time and work have enhanced our knowledge all is not serene, disagreement being only slightly less than in prior years. For the sake of clarity we will deal in principles of history and examination, rather than technique.

May we stress at the start that of all patients examined with traumatic back pain only an exceedingly few should require operative interference, certainly less than 5 to 10 per cent. A sound knowledge and program of conservative therapy is the foundation of all treatment of the back. This involves not only thorough studies of anatomical and postural mechanics, but an understanding of the physiopathologic state of the related organism as a whole.

## CASE HISTORY

The well organized history, as always, is the most important single item in studies of the back. A careful, unhurried history will often provide the diagnosis if properly interpreted. The usual complete medical history routine is desirable with certain specific additions. The following plan is suggested:

### I. Injury:

(a) Nature of injury: direct violence, indirect compression, bending or lifting strain

- (b) Extent and severity of injury
- (c) Prior injuries

### II. Pain:

- (a) Site and radiation
- (b) Severity and quality of pain
- (c) Intermittent or continuous attacks
- (d) Relation of cough or sneeze to local pain and pain radiation
- (e) Relation of pain to normal posture and postural changes

### III. Posture:

- (a) Changes in posture noted by the patient

### IV. Activities:

- (a) Amount of limitation of normal activities such as daily work
- (b) Type of bed mattress habitually used should always be known, as it may be directly related to the complaint

The systematic history may give much useful information. Through it the psychoneurotic personality shows itself, perhaps better than at any other time during the consultation. Of special importance in this phase of the history is a careful evaluation of genitourinary disease.

## PHYSICAL EXAMINATION

Here as in the taking of the history, the whole is to be considered first and not the isolated complaint. Careful observation of the patient's general appearance and a basic physical examination are essential to a correct diagnosis. Listed below are additional specific observations to be made in examination of the low back:

### I. Posture (both static and dynamic):

- (a) *Ambulation*: Is the patient ambulatory? And if so, does he walk with a natural gait and without limp or does he hold himself in an abnormal posture while

walking? Does he favor one leg while walking?

(b) *Ordinary Motions*: It is worth while to observe the patient while undressing or making other movements not related to the physical examination. Observation of the removal of shoes or stockings will give an index of the true amount of back disability.

(c) *Static Posture*:

(1) Foot attitude and distribution of weight between the two lower extremities

(2) Alignment of the legs

(3) Lumbar posture—Is the lumbar lordosis average, increased or decreased?

(4) Cervical and dorsal posture—Is there an average dorsum rotundum?

(5) Lateral list—Is there a tilt originating in the low back area?

(6) Is the pelvis level or tilted?

(7) Lateral deformities of the spine; e.g., scoliosis

(d) *Maneuvers or Tests Related to the Posture*:

(1) Motions of the spine both standing and supine—Right and left lateral flexion. In doing this test, freedom of motion, reference of pain and any difference in the point of origin of motion in the low back are of extreme importance. Any increase in muscle tonicity should be noted.

(2) Flexion of the spine—The ability to complete this maneuver has wide variance but its relation to pain may be of importance in diagnosis. A deviation of the spine to the right or left in forward flexion will indicate unequal muscular contracture in the low back.

(3) Extension of the spine—Any reference of pain from the low back to either or both lower extremities may be of definite diagnostic aid in this test.

(4) Rotation of the spine—In chronic back pain most commonly seen rotation of the spine is not particularly painful. Should the cause, however, be in the facet region, this test will usually be positive with pain production.

(5) Straight leg raising—Limitation in this motion with the patient supine is an indication of both sciatic nerve irritation

and contracture of hamstring and low back musculature. It forms an excellent clinical test of the progress of conservative treatment in low back conditions. Care, however, must be taken in interpreting this test, as a sense of tension restricted to the popliteal space is normal to most patients. Pain along the posterior aspect of the thigh extending into the buttock or low back indicates pathologic change.

(6) The hyperextension test—This may be done in many ways; perhaps the most effective is that described by Duncan and Hoen. The patient is placed supine on a rather high examination table with legs extended over the end just below the level of the hip in such a way as to extend effectively the lumbar spine. When positive, there will be a gradual rising tide of pain following the course of the involved sciatic nerve to thigh and calf. Flexion of the opposite leg acutely at the hip flexes the back and the pain is relieved. It is, of course, particularly useful in the diagnosis of herniated nucleus pulposus.

(7) Pelvic compression—This, to our minds, is the simplest test for true sacroiliac pain of the many that are available. With the patient supine, pressure is placed medially on both outer iliac crests simultaneously. When positive, the patient will localize this pain in the region of the sacroiliac joints.

(8) Local tenderness—The exact site of local tenderness either in the low back area, buttocks or lower extremities should be carefully observed and evaluated at each examination. It should be localized in reference to anatomic landmarks.

## II. *Neurological Examination*:

The tests mentioned here apply principally to the lower extremity. It is wise, however, to include the trunk and upper extremities in this examination to exclude central neuropathologic changes.

(a) *Atrophy*: Atrophy of calves or thighs may be observed by mensuration of circumferences. Gluteal atrophy may be

noted by viewing the prone patient from the foot of the table.

(b) *Reflexes*: Deep response of the glutei, hamstrings, quadriceps and triceps surae should be tested. Abnormalities in the superficial reflexes should be noted as well.

(c) *Sensorium*: Localized abnormalities of skin sensation may be of diagnostic significance, or may aid in localization of spinal lesions. Kinesthetic and coordinational changes may be significant.

(d) *Motor Power*: Evaluation of muscular power and tone is worth while for purposes of diagnosis and localization of the lesion.

(e) *Jugular Compression, (Naffziger test)*: Increase of intraspinal pressures produced by jugular compression may excite pain along the radiation of a nerve affected by an intraspinal lesion. A negative response to this test does not, however, rule out pathologic changes within the spinal canal.

### III. Roentgenological Studies:

Good x-rays go hand in hand with the careful examination. One is incomplete without the other. Suggested routine views are as follows:

(a) Anteroposterior and lateral views of the lumbar and lumbosacral areas.

(b) A 45 degree anteroposterior view of the lumbosacral joint. In this view the central radiations are directed as parallel as possible to the plane of the lumbosacral joint.

(c) If lesions of the small posterior articulations or the sacroiliac joints are suspected, oblique views of the areas involved should be made.

(d) One of the many technics for measuring leg lengths roentgenologically will occasionally be found useful. Other special roentgenological studies will be considered in those conditions in which they apply.

### PATHOLOGY OF BACK TRAUMA

Spinal fractures are excluded from this study as they are a field unto themselves, each being treated on its own merits. Most pain arising from trauma is caused

by changes in the supporting soft tissues. It will be well to consider these changes as they apply to low back pain.

In many instances the lesion is a simple strain or tear of the tendinous insertion of supporting musculature which seldom requires surgical intervention. In recent years our attention is directed more and more to the tissues supporting the intervertebral articulations and to the intervertebral disc.

It will be remembered that the intervertebral disc is comprised of the annulus fibrosus, a series of concentric dense layers of fibrocartilage surrounding the central semi-fluid nucleus pulposus. Support is provided not only by the annular ligament but by other interosseous ligaments and the posterior articular facets.

The lower lumbar articulations support much of the trunk mass and provide greater mobility than other spinal joints, thereby increasing their vulnerability. Ninety-five per cent of back lesions will be found in this area.

Bending or twisting injuries to the trunk will, perforce, place greatest strain near the center of motion, namely, the low back articulations. Lateral and rotary motions are adequately protected by the facets but other forces may produce injury to the annular ligament. This structure is weaker in its posterolateral margin than elsewhere; and since forces applied are usually in flexion, lesions are commonly found in the posterior half of the ligament. The extent of injury may vary from a mild strain to complete rupture with extrusion of the disc forcibly into the spinal canal. The simple ligamentous injury without nuclear protrusion is the usual result of the primary back trauma. It is amenable to a program of support and rest. All too frequently, however, the trauma will initiate a progressive degenerative lesion of the disc structures. The annulus becomes thin and may fibrillate. With or without a secondary injury the now fibrotic nucleus extrudes into the spinal canal exciting radicular pain through its pressure on nerve roots. It is, of



course, possible to have disc extrusion without nerve root involvement, but this is uncommon. Following extrusion, the involved joint generally becomes thin and in time hypertrophic changes will supervene. Nerve roots involved by disc pressure, if not relieved, may in time develop local fibrotic changes and loss of function. Prognosis for relief of pain in these chronic lesions is poor by any method of treatment.

Other structures than annular ligaments may indeed be involved by back injuries, but this structure is the most frequent victim in our experience.

The facet articulations with their surrounding soft parts are subject to strain and injury, and ligamentous tears in the region may lead to chronic back disability. Underlying congenital bony anomalies may enhance the possibility of ligamentous damage following injury and will require careful consideration in planning treatment.

Before considering specific lesions, it will be wise to establish a basis of treatment. The exact source and cause of pain in low back injury is in many instances not known, but it appears safe to say that practically all such pain is related to strain or injury of the soft parts. Physiologic repair of these tissues will require as it does in other parts of the body physiologic rest. Rest then is the basis upon which our efforts of treatment are founded. The type of rest desired will depend upon the condition present and its severity. In the acute low back strain there is no substitute for absolute bed rest. An older method of treatment which is still popular is manipulation under anesthesia followed by immobilization in a plaster of paris jacket or spica for a rather prolonged period. It seems to us that the period of rest thus provided accounts for the beneficial results. In the mild, chronic, recurring back pain in which periods of relief are obtainable, rest of the strained and inflamed ligaments may be actually obtained by effecting a proper postural habit through exercise. Occasionally the use of a back support may aid in achieving this end but it is needed permanently only

in debilitated persons or those refusing operation. Where surgical interference is indicated, absolute rest is obtained through bony arthrodesis. We would re-emphasize the importance of a conservative outlook in the treatment of low back conditions. Surgery, we believe, should be reserved as a final answer, except in those instances that would indicate chronic disability without it.

#### HERNIATED NUCLEUS PULPOSUS

It was a brief fifteen years ago that Barr and Mixer first described this condition and its part in the production of pain. In that short period this diagnosis has become more frequent than almost any other as a serious cause of low back disability. There is no doubt that in this wave of popularity the diagnosis has often been misused, but with added experience and new methods, much greater accuracy is now possible. We are able, therefore, to describe the symptoms of the "typical" disc lesion. Before doing so, however, the reader must be warned that here as elsewhere there is always the atypical occasional case to challenge our diagnostic skill.

The complaint is one of sciatica; pain is distributed down the posterolateral aspect of the thigh into the lateral aspect of calf and foot, and back pain is present. Low back pain will usually have been initiated by bending or lifting strain. The pain improves and is then followed by leg pain. It is not at all infrequent, however, that back pain has not been present at all and sciatica has been the only complaint. Pain is usually intermittent but in nearly 25 per cent of patients it will have been more or less continuous. Leg pain is increased on coughing, sneezing or on straining at stool. The patient has noticed some change in his posture, one hip becoming more prominent. He is most uncomfortable on sitting for long periods; standing in one place is also tiresome. He is usually happiest while walking; and rest in bed, if carried out over a long period, will tend to give him some relief. The examination will



reveal that he tends to take most of his weight on the painless foot, and he stands with a list away from the side of the pain. The lumbar lordosis is flattened and there is increased muscular tonicity in the sacrospinalis groups. In seeking comfort, he will tend to flex the painful leg at hip and knee. Lateral bending to the side of the lesion will produce increased radiation of pain down that extremity. Extension of the spine will do likewise. Rotation of the spine is usually free and painless. Straight leg raising will be definitely limited and painful on the affected extremity, and there will usually be tenderness over the spinous process of either L<sub>4</sub> or 5 or over the paravertebral musculature on the affected side. Where the pain has been of long standing there will be thigh, calf and buttock atrophy, and there will be loss of buttock tone to be tested by palpation of the glutei. The tendo-achilles reflex on the affected side is most often absent, but other reflexes may be diminished in its stead. The gluteal reflex is frequently found diminished or absent. In cases of any severity, there will be tenderness along the course of the sciatic nerve in the buttock and thigh. A localized point of tenderness is frequently found on deep palpation of the gluteus medius muscle just above the greater trochanter of the hip on the affected side. The lesion occurs in 95 per cent of patients either in the fourth or fifth lumbar interspaces. Therefore, deep percussion in this area will frequently produce sharp radiating pains along the course of the affected sciatic nerve. There is frequently weakness of big toe flexion and/or extension. Sensory examination will show hypesthesia or anesthesia along the dermatomes of L<sub>5</sub> or S<sub>1</sub>, the latter being the most common. Jugular compression will usually produce pain along the sciatic radiation and the extension test described above is most frequently positive. It must be reiterated that the above findings represent the average and that variance in one or more is by no means uncommon. The spinal list, for example, may rarely be toward the side of the lesion rather than away or may

actually alternate from one side to the other within the period of a single examination. This latter finding usually indicates a midline disc lesion.

There are certain special roentgenologic technics which will be of great help, not only in establishing the diagnosis but also in localizing the lesion and in determining the type of operation to be done. The routine low back x-rays may indicate the site of the lesion through a narrowing of the affected intervertebral space. This, however, is not usual in the young adult who has suffered for only a short period. When this occurs at the lumbosacral junction it may be misleading as this joint is frequently congenitally narrow. Anteroposterior films, showing lateral bending of the lumbosacral spine will in about 40 per cent show a failure of closure on one side of the disc space involved. We do not believe that this test is diagnostic, but it may be a definite aid in localization of the lesion. Probably the most important radiologic development has been the myelogram. At first this was done with air or oxygen but has been generally found inexact because of failure of sharp contrast. Lipiodol was then injected into the dural space and gave an excellent picture but was found to be rather difficult to remove *in toto* and dangerous if left in place, as in many instances it produced subarachnoid irritation. A new substance, pantopaque, has been developed in recent years as a contrast medium. (Fig. 1.) It is said to be non-irritating on the meninges. It is somewhat easier to remove after the myelography has been done by needle than was lipiodol and any that is left in place is slowly absorbed without producing pathologic changes. The technic is simple but requires some care, patience and expert roentgenologic interpretation. While the diagnoses thus obtained from positive roentgenograms are very definite, it must be borne in mind that a disc protrusion may exist without showing any change in the column of contrast medium. As shown by Spurling, the mere absence of an axillary node in the shadow may be diag-

nostic, and it is such minimal findings that will require careful interpretation. Above all, a pantopaque myelogram helps us to anticipate the finding of cord tumor, cyst or other intraspinal lesion instead of the expected disc.

While discussing special tests it is wise to mention spinal puncture and cerebrospinal fluid analysis. This is generally not considered as important in the average case as it was a few years back, the reason no doubt being that we now have a better understanding of the clinical findings indicative of disc. In any case in which myelogram is done, spinal fluid should be obtained and studied. In a doubtful case, even though myelogram is not planned, a spinal fluid study is certainly indicated. More often than not the spinal fluid in the true disc will be found to be normal, but slight to moderate elevations in spinal fluid protein content are not at all unusual. The value of the spinal fluid study is most important in ruling out other sources of complaint.

The decision as to the choice of treatment to be employed will depend upon a number of factors. To the general medical profession as a whole the diagnosis of herniated nucleus pulposus seems to predicate surgery as the only form of relief. Since the lesion may vary from a mild strain of the annular ligament to a complete eruption of the entire nucleus into the spinal canal, this above impression is by no means true. The majority of disc lesions can be successfully treated conservatively. Where long periods of complete relief have been experienced between mild typical attacks of pain, conservative treatment by rest, supervised exercise and possibly brace is usually successful. In such instances, however, when a period of absolute bed rest over a period of one to three weeks fails to give subjective relief or improvement in objective findings, operative interference is indicated. In patients with acute pain following closely on initial trauma, a period of bed rest will be the best indication as to the type of treatment to be



FIG. 1. Pantopaque myelogram; large defect is present at lumbosacral level, left.

followed. It is rare that operation is needed at this time, and properly applied conservative treatment allowing complete healing of the injured disc ligaments may do much to prevent recurrence of the difficulty in the future. If, however, clinical changes as outlined above persist in spite of carefully administered rest, operation will be the logical choice in order to prevent permanent nerve root injury.

There are certain patients seen with extreme symptoms from the onset which demand early operation without thought of conservative treatment. These patients are admitted to the hospital by ambulance because they are completely unable to walk. The pain is excruciating no matter what the position. Examination is well nigh impossible because of the extreme discomfort any motion of the affected extremity or back produces. The neurologic symptoms and signs are usually outstanding. Procrastination and conservative treatment fail to give relief unless eventually the function of the nerve root is destroyed through pressure. Early operation will not only provide a much appreciated relief

but will prevent serious permanent cauda equina damage. At operation a large completely herniated lesion is usually the finding in this type of patient.

#### OPERATION

In all patients in whom the above requirements have been fulfilled, exploration of the involved disc is indicated. If this proves negative, certainly the associated disc spaces should also be explored. Many surgeons believe that the disc spaces of both L<sub>4</sub> and L<sub>5</sub> should be routinely explored as double discs are reportedly not uncommon findings. It is not our purpose to discuss the technic of exploration in this paper. One of the major questions arising, however, will be whether or not a concomitant spine fusion should be performed. At the present time this problem is under discussion in many places. In the early experience with disc operation, only a relatively few patients received spine fusion. In studying end results, various series have been reported up to 50 per cent recurrence of back pain in which this has been the routine. There has been, therefore, a swing of feeling in favor of early fusion but the issue is by no means settled. Many believe that in the young, healthy adult in whom x-rays reveal no bony change from the normal, fusion should be omitted, and the patient allowed the briefer hospitalization afforded by simple exploration and excision of protruded disc material, reserving fusion for those patients only in whom x-rays indicate definite disc narrowing or in whom degenerative arthritic change is already apparent. It is our opinion that even with simple exploration without fusion the patient should have activities restricted for a longer period than has been customary in the past to allow repair changes to mature in the operated intervertebral disc and thus prevent possible recurrence. With the development of new technics of spine fusion which will be discussed briefly below, the period of hospitalization required after spine fusion has been materially reduced.

We deem it, therefore, a better policy routinely to fuse the vertebrae involved to the sacrum following removal of the disc unless there be some extenuating circumstance of health or economics that makes such a course unwise. The area of fusion, we believe, should be inclusive only of the site of the disc lesion to the sacrum. If the disc be found between L<sub>5</sub> and S<sub>1</sub>, we see no apparent reason for including L<sub>4</sub> in the fusion area. The danger of pseudarthrosis in the fusion area must always be borne in mind as a general rule in fusing to the sacrum. The more joints fused the greater this risk.

#### LOW BACK STRAIN

This non-specific diagnosis indicates soft tissue rather than bony injury localized to the low back and not affecting specific nerve roots, and as such, forms the commonest classification of acute primary back pain resulting from trauma. The condition itself seldom, if ever, requires operative interference as it is particularly amenable to rest. In chronically recurring low back strain, basic underlying structural weakness must be suspected. This will be discussed in another section. The lesion in low back strain is most commonly ligamentous tear of varying severity; the pain is thus localized to the back area to one side or the other or occasionally in the midline. Infrequently, ligamentous injury may be adjacent to neural foramina, the resultant edema producing nerve root pressure and some sciatic radiation of pain. The rapidity of recovery following institution of bed rest will give a clue as to the etiology of such pain. Very rarely fascial injuries may be severe enough to require operative repair. This is seen specifically in herniation of the lumbodorsal fascia which can be diagnosed by the prominent painful mass present at the site of rupture.

#### STRUCTURAL ANOMALIES

In no part of the human skeleton are variations in bony anatomy more prominent than the lumbosacral region. It is

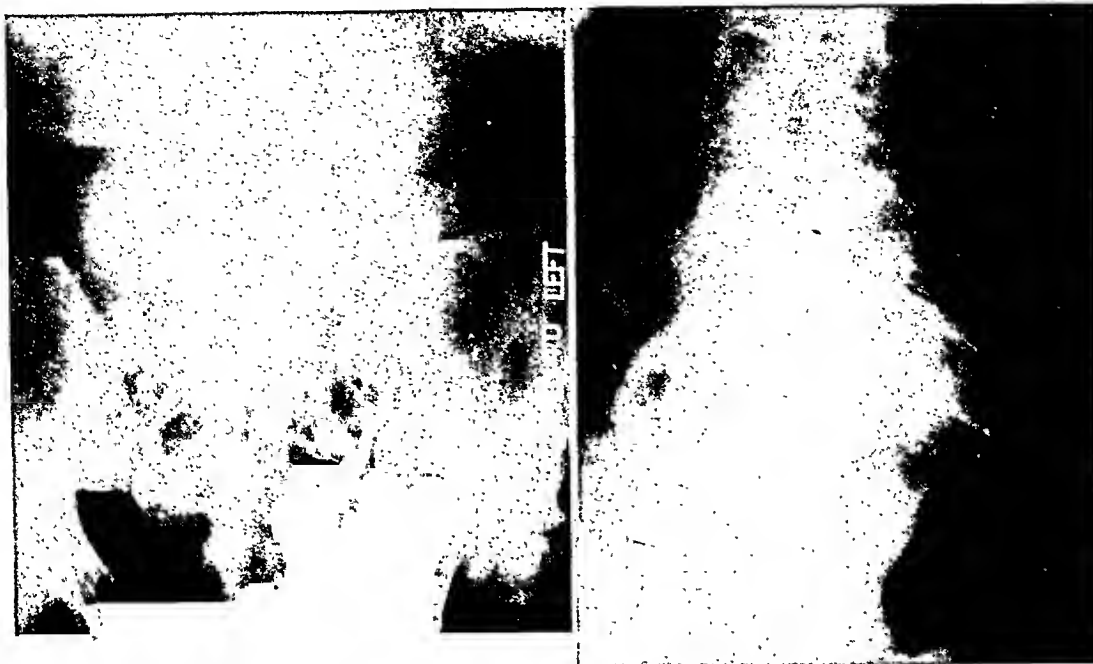


FIG. 2. Congenital variation in the lumbosacral joint. The left transverse process of L<sub>5</sub> is sacralized. There is also a pre-spondylolisthesis.

quite safe to say that no two low backs are exactly alike. These variations show themselves in mild forms as alterations in the thickness of the lumbosacral joint, variations in the angle between the lumbar spine and sacrum or variations in the plane of the small posterior articulations. In more severe instances, transitional vertebrae will be found between those of true lumbar type and those fused to form the sacrum. (Fig. 2.) There may be articulation or fusion of one or both transverse processes to the sacrum or ilium, and the level of the functioning lumbosacral joint is thus elevated. In extreme instances there may be failure of fusion between the ossification centers of the vertebral body to those of the pedicles and laminae producing spondylolisthesis. (Fig. 3.) This occurrence has been estimated as high as 4 per cent by some observers. Rarely, hemivertebrae are seen in this area. These congenital variations are not of importance in themselves unless there is complaint of back pain. There can be no doubt that many people go through life with such changes in a severe degree without ever having back complaint. However, in relation to heavy work and injury, their presence may be of importance as they may be the source of an underlying archi-

tectural weakness which will subject the associated soft tissues to strain and injury. It should be noted that these findings become an indication for operation only when there is a history of recurrent back pain not permanently alleviated by conservative measures. Many physicians will probably be of the opinion that spondylolisthesis renders the patient in imminent danger of complete dislocation and paralysis through cauda equina pressure or section. This is by no means true as it is unusual to find more than slight change in vertebral displacement over long periods of observation, even though the patient may be doing heavy labor. The term, lumbosacral instability, is frequently used to classify the milder anatomic changes often seen. It is perhaps better to use a specific diagnosis where possible.

Underlying structural weaknesses in the lumbosacral area may result from (1) Anatomical changes elsewhere, (2) local disease or (3) previous injuries.

Idiopathic or other type of scoliosis at a higher level in the spine will produce a compensatory curve below with unequal distribution of weight and strain upon the lumbosacral joint. Soft tissue contractures involving the back or abdominal muscula-

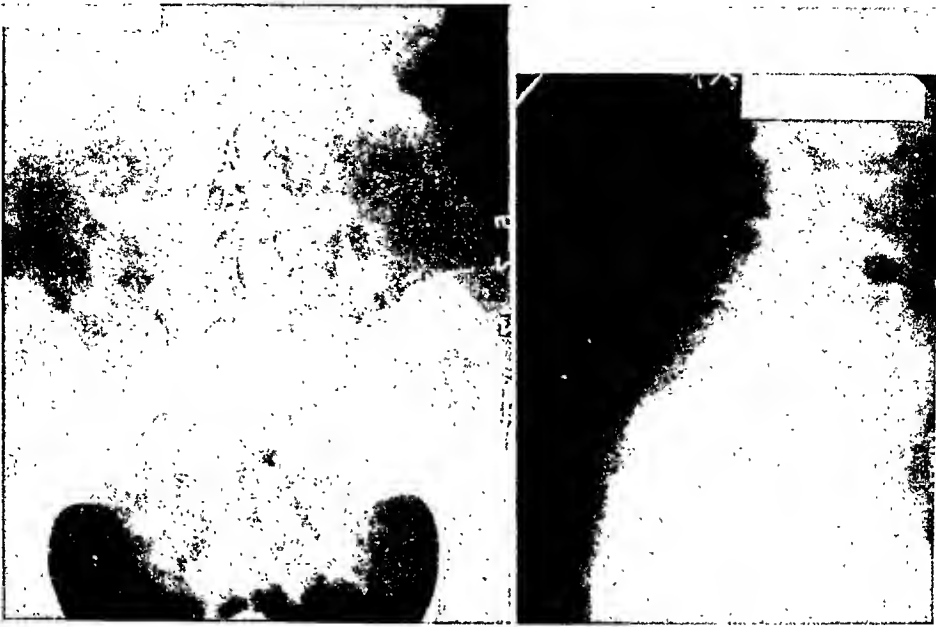


FIG. 3. Spondylolisthesis; L5 is almost completely displaced anteriorly on S1.

ture may have the same effect, and a similar mechanical change is produced by differences of leg length which result in pelvic tilting. Joints thus affected are more readily strained than normal ones and may be a cause of recurrent back pain following even mild injury.

Joints or vertebrae that have been previously the site of infection or tumor may be affected structurally producing definite mechanical changes in relation to the soft parts; articulations affected by previous arthritis may represent a weak point, and involvement of a joint during the growth period by an epiphysitis may produce similar change.

Joints previously involved in severe trauma are thus weakened and may develop changes of a productive arthritis with the passage of time. This trauma may have resulted in either ligamentous or disc injury or fracture. The residual joints will not have normal mobility as a rule and will either be a source of recurrent strain from trauma or place excessive strain on surrounding structures with resultant pain. The operation of choice in any condition producing instability is again spine fusion of the involved parts. When this is in the low back, it is usually wise to have the

sacrum included in the fusion, thus avoiding excessive strain on the lumbosacral joint even though it may not be involved.

#### THE FACETTE SYNDROME

This term is used to designate instability of one of the small posterior articulations in the spine. It occurs largely in the lumbar spine, usually in the lower vertebrae. The small posterior articulation on one side or the other as a result of trauma may either be subluxated or actually dislocated. The patient while straining feels a distinct and almost audible and snapping sensation, has immediate pain and finds that he has severely listed and flexed. There is local back pain, usually paravertebral, at the site of the lesion and there may or may not be radiation of pain either into the groin or along the course of the sciatic nerve. Should the lesion be only a subluxation, the patient will find that on rest, posture will gradually return to normal. If a true dislocation has occurred, he will rarely be able to attain reduction by his own efforts. The injury, of course, is primarily a ligamentous one, but in time there should be distinctive changes noted in x-rays of the joint involved. Oblique views, in many instances, will provide the diagnosis even

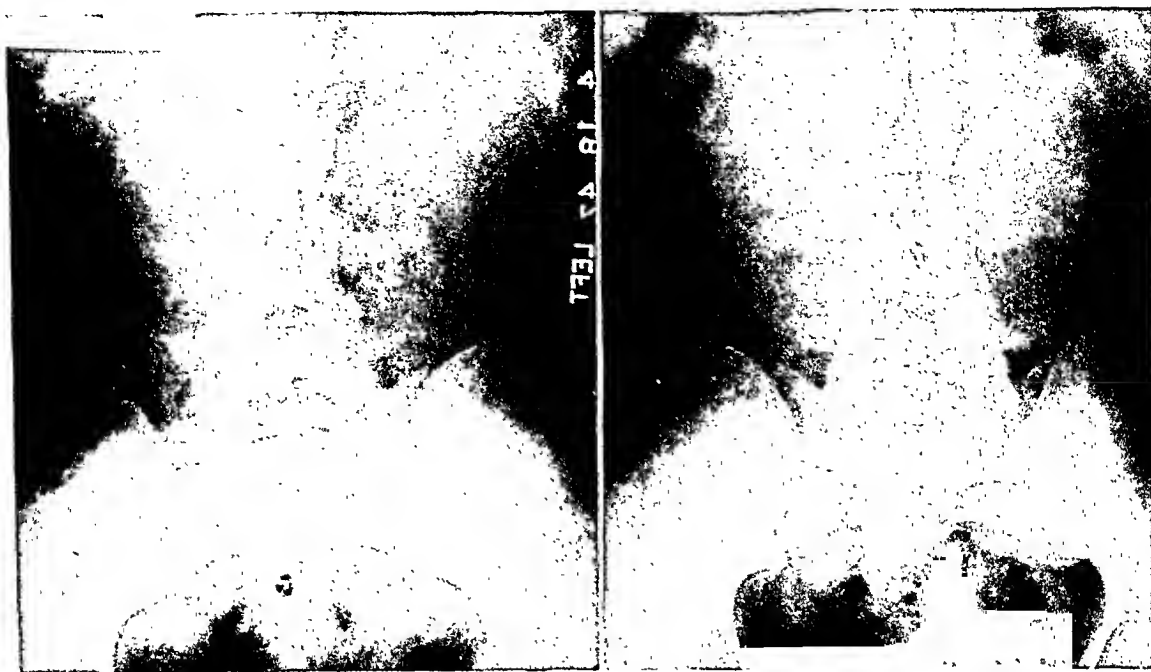


FIG. 4. Early Marie Strumpell arthritis occurring in identical twins at twenty-one years of age. Early changes are present in the sacroiliac joints. (Courtesy of Dr. R. H. Freyberg.)

though dislocation is not actually present at the time of examination. The facet space will be narrowed and may present hypertrophic changes not present in other areas of the spine. Nerve root pressure is produced through both mechanical narrowing of the foramen of exit of the spinal nerve, and resultant edema in the associated soft tissue. In the earlier phases, reduction and a careful trial of conservative treatment are usually successful; and if treated at the primary occurrence, permanent relief is common. If the condition, however, becomes recurrent, spinal fusion operation is the treatment of choice. This diagnosis does not seem to be made as frequently as a few years back, and it is probable that many cases thought to be facet syndrome were in reality disc lesions, especially those in which the disc had protruded itself in or near the neural foramen. Where doubt of diagnosis exists, exploration of the disc should no doubt be done accompanied by a foramenotomy if necessary.

#### SACROILIAC TRAUMA

The diagnosis of sacroiliac slip or strain is no longer the catch-all that it was just a few years ago. It is made still, however,

with far greater frequency than it warrants. The sacroiliac joint is without doubt one of the strongest articulations in the human skeleton. Its ligaments are powerful and numerous. It is doubtful that any but the most severe injuries will affect this joint. This is borne out by the findings in motor accidents where shearing force is placed upon this joint. It is most usual to find a fracture through the ilium rather than a dislocation of the joint itself.

The sacroiliac joint that has been involved by infection, arthritis or epiphysitis, however, represents a different problem and frequently may be the cause of recurrent back pain associated with mild trauma. Changes related to injury must not be confused with early Marie Strumpell spondylitis, as it will be recalled this disease produces its first lesions in the sacroiliac joints. (Fig. 4.) Clinically the shearing test or compression of the pelvis as described above will indicate a localized pain over one or both sacroiliac areas. X-rays, especially oblique views of the sacroiliac area will readily support the diagnosis. The blood sedimentation rate may be of differential value. Where disability is sufficient or recurrence is frequent, operation is again the treatment of choice,

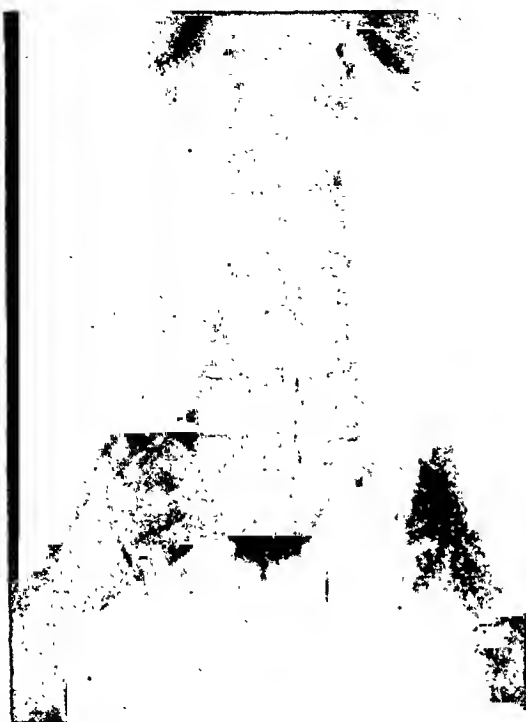


FIG. 5. Postoperative roentgenogram illustrating the use of both the spinal plate with bolts through spinous processes and the facet screws as internal fixation. A massive iliac graft and bone chips provide the osteogenic basis of solid bony fusion.

sacroiliac fusion being the most effective. Before doing this procedure, however, careful studies must be directed to the lumbar spine to rule out any concomitant pathologic condition in that area. If necessary, a trisacral fusion may be done at one operation.

#### OTHER PROBLEMS

There are certain patients in whom low back pain will be a cause of disability where no specific anatomic diagnosis can be made. They may present mild postural changes and will show sufficient muscle contracture and spasm to indicate that the complaint is not entirely subjective. Neurologic and roentgenologic studies will be consistently negative but conservative treatment will fail in its aim to give permanent relief. In some instances, we have demonstrated excessive motion of L<sub>5</sub> on S<sub>1</sub> as seen in the lateral projection with a slipping of L<sub>5</sub> backward at this point. We believe that a diagnosis of true lumbo-

sacral instability may apply and with the failure of conservative treatment, fusion operation should be undertaken. In all patients, no matter what the indication, a careful evaluation of the psychic factors involved must be made. This probably represents the difficult problem for the orthopedist. Psychosomatic factors in relation to the low back are assuming ever increasing recognition at the present time, and it may be safely said that no back pain is without its psychic manifestation. Add to these, the problems of compensation or liability, and the decision as to whether or not to operate becomes exceedingly difficult. Rapid decisions in this regard are, therefore, not to be taken, as the faithfulness of the patient in doing exercises and his general behavior over a period of observation will give much desired information in this regard. Where these factors are prominent, a successful fusion will seldom give complete relief.

#### TYPE OF SPINE FUSION OPERATION

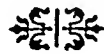
Since the original work of Albee and Hibbs on the subject of spine fusion, there have been many modifications developed in technic which for the most part have been relatively unimportant as far as successful fusion was concerned. As experience with the procedure and increased knowledge of the status of bone transplants has been obtained, certain basic rules have become increasingly apparent and modifications based on these principles promise an improved percentage in good end results. With the addition of two methods of secure internal fixation in spine fusion, either spine plate or facet screws, the prolonged postoperative immobilization required of simple grafting methods is overcome. (Fig. 5.) We believe that in those instances in which internal fixation is not available immobilization of from eight to twelve weeks in a plaster spica is essential to overall success. Spine fusion with internal fixation requires no immobilization in plaster if the fixation is demonstrably secure during surgery. It has



been aptly demonstrated that bone healing is most rapid when cancellous material rather than cortical bone is employed. Therefore, except in those cases in which a rigid bone graft is desired, the ilium is the donor site of choice. With the proper development of the bone bank, the source of bone transfers will be greatly simplified. Spine fusion itself must always be a serious undertaking and the surgeon must do a thorough and painstaking procedure if he is to assure success.

#### CONCLUSIONS

It has been our purpose in this paper to present the operative indications in low back states resulting from injury. The important elements of history and physical examination have been reviewed and some specific lesions discussed. Throughout we have stressed the importance of care in observation during both clinical examination and of special diagnostic aids before a surgical program is undertaken.



WHEN the spinal cord is divided completely, and if the patient survives, the immediate effect on the bladder is paralysis and retention of urine. In gunshot wounds of the spine the cord is often cut across or is pulverized by the missile; in other instances the same effect is produced by forcible impaction of a piece of bone.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams & Wilkins Co.).



# COMMON SHOULDER INJURIES\*

## DIAGNOSIS AND TREATMENT

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COMMON shoulder injuries are simple problems when treated by a program founded upon a knowledge of the normal functional anatomy of the part. However, the therapeutic program must be tempered by a clinical philosophy which includes comprehension and acceptance of certain proven truths pertaining to the shoulder mechanism:

1. The only useful functions served by complete immobilization or partial restriction of function of the injured adult shoulder include: (1) local rest of recently damaged tissues, (2) protection against additional damage and (3) maintenance of bone to bone apposition when aiming for scapulo-humeral arthrodesis in the position of maximum function.

2. The inevitable harmful function served by immobilization or restriction of function is the production of a rapidly progressive muscular imbalance, atrophy, stiffness of the joints and prolonged pain and disability.

3. Improper treatment often imposes a more severe penalty upon the patient than would a complete absence of treatment.

4. Considerable derangement of any single motor skeletal component of the shoulder is possible without significant interference with total function.

5. The most important single factor predisposing to unsatisfactory results in common injuries of the shoulder is the utilization of therapy based upon the anatomical or x-ray characteristics of the injury to the exclusion of all other factors. The presence or absence of normal anatomy, while desirable, is not especially important to the proper functioning of the shoulder mechanism.

## FRACTURES AT THE UPPER END OF THE HUMERUS

*Diagnosis.* Gross deformity demonstrable by clinical evidence is frequently absent, obscured by swelling or difficult to palpate in the presence of acute pain and spasm. All injured shoulders deserve x-ray examination. Adequate roentgenographs demonstrate not only the exact level and extent of the fracture but also the presence or absence of associated complicating features. An anteroposterior view is essential. It is often difficult to obtain a good lateral film of the acutely injured shoulder. However, if a film is taken with the patient standing and the anterior aspect of the injured shoulder against the cassette at such an angle that the central ray parallels the spine of the scapula, a very satisfactory oblique view may be obtained. In thin patients a film taken through the thorax may provide a very adequate true lateral view of the lesion. One or the other is essential to demonstrate accurately the degree of anterior or posterior displacement present and to evaluate the relationship of the fracture fragments to each other and to the scapula.

All objective evidence should be evaluated and certain tests carried out in every case:

1. *Neurological and Vascular Status of the Extremity.* The functional integrity of the brachial plexus and the vascular mechanism always should be evaluated. This requires not more than a few seconds in the average case. If the patient is able to flex his fingers, extend the wrist and spread the fingers apart the median, radial and ulnar nerves, respectively, are intact. In any

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case of doubt sensory examination should be done to confirm or exclude the presence of nerve involvement. The sensory function of the axillary nerve should be tested by pinprick over the skin of the deltoid area. Hypesthesia rather than anesthesia is to be expected if the nerve is damaged. In the presence of an acute injury motor function of the axillary nerve (deltoid muscle) is usually precluded by pain, but it is seldom difficult to appreciate the presence of muscle tone sufficient to indicate that the motor power of the nerve is intact. Vascular integrity should be established by evaluation of the pulse or nail bed circulation, using the normal extremity for comparison. Negative as well as positive findings should be recorded at the original examination for the protection of both doctor and patient.

2. *Swelling.* Swelling is the most accurate available measure of the extent of soft part damage. The amount of soft part damage varies directly with the speed and degree of swelling and the tension of the tissues. Upon this evaluation should depend the decision to give casual or intensive physical therapy designed to eliminate the locally toxic products of pathological conditions of the soft parts.

3. *Ecchymosis.* Ecchymosis occurs late, usually three to seven days after the injury. At this time it is seen just proximal to the elbow on the medial aspect of the arm and at times on the medial wall of the axilla. Early ecchymosis over the deltoid area indicates laceration and perforation of muscle and fascia by a bone fragment. This should immediately arouse suspicion of interposition of soft tissues between the fragments which may be confirmed or ruled out by the absence or presence of bony crepitus at the fracture site. If crepitus cannot be obtained, one attempt at closed reduction may be warranted; but if this is unsuccessful or unduly difficult, the procedure of choice is an operation for removal of the interposed tissue and open reduction of the fracture. Repeated unsuccessful attempts at closed reduction accomplish no good and each does considerable

additional damage to the soft part components of the shoulder mechanism.

4. *False Motion or Impaction at the Fracture Site.* Before a treatment program is decided upon it should be ascertained whether there is false motion between the bone fragments or whether they are impacted sufficiently to move in unison. In order to make an accurate estimate the examiner should stand behind the injured shoulder, place one hand lightly on top of the shoulder so that the finger tips rest on the humeral head just anterior to the acromion and grasp the flexed elbow of the injured extremity with his other hand. As the elbow is then gently rotated to and fro the presence or absence of motion of the humeral head in concert with the shaft may be palpated accurately. This technic of examination is emphasized because adequate palpation of the humeral head from the front or side is extremely difficult and often impossible.

5. *Bony Deformity.* Gross bony deformity is uncommon. Usually the bone ends remain in contact. When complete displacement exists the deformity follows a consistent pattern. The upper end of the shaft fragment is pulled medially and forward by the pectoral muscle. Overriding results from the pull of the long muscles of the arm. Shortening is measured by a comparison of the distance between the acromion and the lateral epicondyle with that of the normal side. Medial and forward displacement is apparent on visual comparison of the long axis of the arm with that of the normal side.

#### TREATMENT

The penalty of improper treatment is greater than that of the untreated fracture. Lesions of the upper humerus take place through vascular cancellous bone. The surgical neck and either or both tuberosities may be involved and at times an intra-capsular fragment of the head may become separated from the parent bone. Classification of upper humerus fractures according to location is of little or no therapeutic

significance. As a group they may be divided into two main categories, those requiring reduction and those that do not.

*Lesions not Requiring Reduction.* This group, with infrequent exceptions, includes all fractures of the upper end of the humerus in which the bone fragments remain in contact. This statement is based upon critical analyses of the end results in a large number of cases treated by various methods and has been substantiated by the accumulated experience of many authoritative clinics. The basis of its validity rests upon the following facts:

1. Bony healing is rapid and certain regardless of the type, presence or absence of treatment.

2. Excellent function is to be expected despite bony deformity. This fact is at complete variance with the statement of Watson-Jones that failure to correct deformity results in limitation of motion by a degree corresponding to that of the deformity. Careful analysis of a large series of adequately followed cases demonstrates conclusively that bony deformities *per se* in the upper end of the humerus have little, if any, functional significance.

3. Prolonged stiffness and disability, a certain amount of which often proves permanent, result from immobilization.

4. Immobilization is unnecessary to maintenance of position. The fragments are stabilized sufficiently by the long biceps tendon and the remaining intact soft part attachments so that displacement further than that incurred at the time of injury rarely occurs. The weight of the dependent arm provides enough traction to maintain axial alignment of the fracture. Impaction is common and even when this is not present at the start, union sufficient to enable all fragments to move in unison usually occurs within two weeks.

Comprehension of these four well proven facts simplifies the therapeutic problem considerably. Since reduction and immobilization is necessary neither to bony union nor function the optimum treatment has only to provide the following: (1)

Relief from pain; (2) protection against further damage; (3) maintenance of function of the soft part components of the shoulder mechanism. The following program adequately accomplishes these objectives:

The extremity is dressed in a sling and bound to the thorax by a swathe to provide protection, local rest of the injured tissues and relief from pain. The sling should be applied so that it suspends the extremity at the wrist rather than the elbow, thereby allowing the weight of the arm to act as a beneficial traction force. The weight of the arm alone provides sufficient traction for all fractures at or proximal to the surgical neck of the humerus. The use of a hanging plaster is unnecessary and detrimental to a good result. The swathe should bind the arm to the chest snugly enough to restrict painful motions during the early stages, but except when required for protection against external forces beyond the patient's control it should be discarded as soon as symptoms permit. Aspirin, codeine, gentle local heat, sedative massage and any other soothing measures available are useful to control pain and spasm, especially during the first week following injury. It should be explained to the patient that any restricting dressing applied is for support, protection and comfort and not designed to immobilize the arm; and that the resultant restriction of motion is a necessary disadvantage of the early stages of therapy which must be compensated for by added effort on his part as soon as diminishing symptoms permit gradual progressive resumption of motion.

Active, gravity-free motion is possible and should be started within a few days or as soon as pain permits. All dressings are removed and the arm allowed to hang at the side. The patient then is made to bend forward with the arm still hanging limp. Gradually, gently, but in a progressively increasing arc, he is instructed in swinging the dependent arm pendulum fashion. As the symptoms subside the scope

of these pendulum exercises are increased. Pain is the accurate measure of safety in evaluating the degree of activity to be permitted at any stage. Further displacement will not take place without further laceration of the surrounding soft part stabilizers of the bone fragments. Any strain sufficient to jeopardize these structures is signalled by pain. So long as motions and exercises are maintained within pain limits there is no danger of increasing the existing deformity.

Within two weeks symptoms usually subside sufficiently to make pendulum exercises free and fairly comfortable. By this time the fragments are healed enough so that clinical examination demonstrates them to move in unison if this was not true at the onset. Gradual progressive resumption of aided active elevation against gravity then should be instituted. This may be done by teaching the patient how to crawl up the wall, and to throw a rope over a door, a shower rod or a pulley and carry out gibbett exercises. Coincident with subsidence of pain and the progressive recovery of function every effort should be directed toward resumption of normal use of the extremity within pain limits. Normal use which calls for synchronized action of the shoulder muscles is much more efficient than any prescribed exercise and should always be started at the earliest possible moment and gradually but progressively increased in scope. As soon as the symptoms permit the sling and swathe should be discarded for progressively increasing periods and then left off altogether except when needed for protection against external forces and when he is asleep. The absence of pain and the recovery of function indicates the time when full normal activities are permissible. The x-rays should be ignored in making this decision.

*Fractures Requiring Reduction.* These fractures include lesions with complete displacement, i.e., no contact between the fragments, and an occasional grossly angulated lesion at the surgical neck.

*Reduction.* The typical deformity consists of a displacement of the proximal end of the shaft fragment forward and into the axilla with some degree of overriding. The proximal fragment or fragments usually remain relatively unaffected by muscle pull. Displacement of the distal (shaft) fragment results primarily from the action of the long muscles of the arm and the pectoral group. Neutralization of both offending forces is necessary to reduction. The pectorals are in maximum relaxation when the arm is flexed and adducted. Traction is necessary to overcome the pull of the long muscles of the arm and restore the length of the humerus. Therefore, if bone length is restored by traction in the flexed and adducted position, completion of the reduction by manipulative eradication of the displacement caused by the pectorals becomes a simple maneuver. Attempts to reduce the deformity described above with the arm in any position other than flexion and adduction are contrary to the anatomical factors involved and very apt to be unsuccessful.

Failure to obtain a satisfactory reduction on one, or at the most two, technically adequate attempts usually is indicative of interposition of soft tissue structures between the fragments. Open reduction should then receive prior consideration over further manipulations which are no more likely to be successful than the first attempt. Each additional manipulation, no matter how expertly it is carried out, creates considerable additional soft part damage which may be followed by more disastrous results than the primary lesion. It is probably safe to say that any lesion which requires repeated forcible manipulations is either being reduced improperly or is characterized by some unrecognized complicating factor which precludes reduction by manipulative methods.

*Maintenance of Reduction.* Whenever possible reduction should be followed by an attempt to impact the reapposed fragments by manual compression in the long axis of the bone applied at the elbow and

shoulder. After this has been accomplished, or even if the attempt to impact has failed, the arm should be gently brought down to the side from its reduction position of flexion and adduction. If bony contact remains with the arm in a dependent position, treatment may proceed along the lines discussed for fractures not requiring reduction.

If loss of contact between the bone ends recurs when the arm is brought to the side, more energetic measures for maintenance of reduction become necessary. These must provide maintenance of normal bone length and relaxation of the pectoral muscles. An efficient method of accomplishing these two objectives consists of skeletal traction by a Kirschner wire through the olecranon with the patient in bed and the arm flexed and adducted. More than ten days of bed rest and maintenance of reduction by such a program is rarely necessary before clinical examination demonstrates the fragments to move in unison as the arm is gently rotated. The traction then may be removed, the arm brought to the side and the lesion treated by a program identical to that described for similar fractures not requiring reduction.

*Isolated Fracture of the Greater Tuberosity.* This lesion is common and often over-treated. So long as the tuberosity fragment remains in contact with the parent bone it is without therapeutic significance and should not be treated as a fracture in the usual sense. Nothing by symptomatic therapy is required. Continuance of function up to pain limits should not only be permitted but insisted upon. A sling should be used no longer than is necessitated by pain. Recovery is rapid and in the absence of associated intrinsic tendon damage usually is complete.

#### ANTERIOR DISLOCATION OF THE SHOULDER<sup>3,8,10,11</sup>

*Diagnosis.* Clinical diagnosis of the dislocated shoulder is simple if the lesion is looked for. Inspection always shows an abnormal deviation of the long axis of the

humerus as compared to the normal side. Viewed from in front the long axis deviates toward the base of the neck, and as inspected from the side it passes anterior to the acromion. These abnormal phenomena are always apparent even in the most obese patients. The normal rounded contour of the shoulder is replaced by a flattened deltoid hanging from an unduly prominent acromion process, but this appearance may be obscured by obesity or local swelling. In thin patients the infraclavicular fossa often is obliterated or replaced by a bulge caused by the displaced humeral head. The absence of the humeral head from its normal subacromial position almost always is palpable.

Certain other tests of importance should be done in every case:

1. Pinprick evaluation of skin sensation over the deltoid. Approximately 30 per cent of anterior shoulder dislocations demonstrate evidence of axillary nerve damage in the form of hypesthesia in its sensory distribution. Usually this evidence disappears following reduction. If not, management of the neurological lesion in concert with the treatment of the dislocation becomes imperative.

2. Evaluation of the circulatory status of the extremity and of the functional integrity of the median, ulnar and radial nerves, any or all of which may be involved at the site of the dislocated humeral head.

3. Measurement of arm length from acromion to lateral epicondyle and comparison with the normal. Anterior dislocation produces, if anything, a slight increase in this measurement. Gross shortening should be considered pathognomonic of fracture dislocation with imminent danger of serious damage to the neurovascular structures in the axilla until proven otherwise by x-ray.

4. X-ray films should be obtained in every case as soon as possible. The majority of complicating factors mitigating against successful therapy by routine methods are present and discernible in pre-reduction films.

*Fracture of the Greater Tuberosity.* This lesion is present in 25 per cent of anterior dislocations. It is not a complication when the tuberosity fragment remains in approximately normal position and embedded in the empty capsular sleeve from which

Such a circumstance is pathognomonic of a massive avulsion of the short rotator tendons from the head of the humerus. This is a crippling lesion and operative intervention is indicated at an early date if a useful shoulder is to be regained.

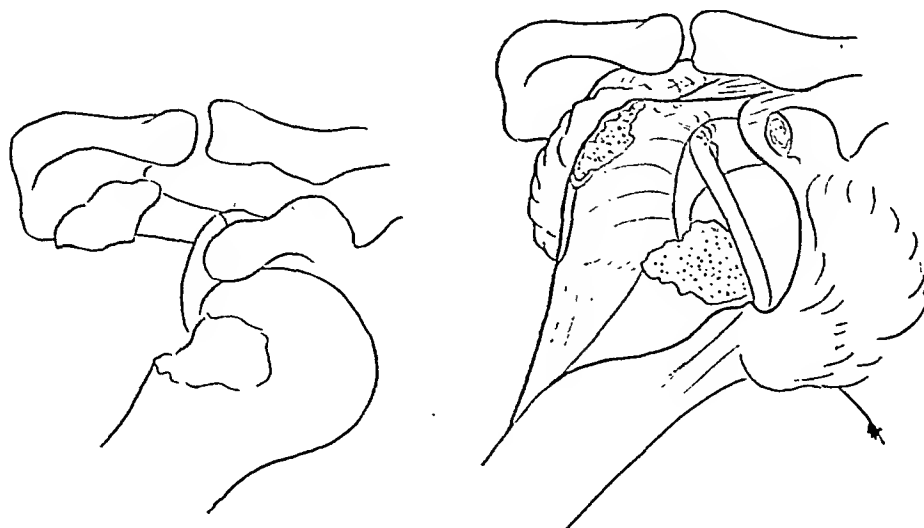


FIG. 1. Left, tracing of x-ray film showing anterior dislocation and fracture of the greater tuberosity. The fracture fragment remains in approximately normal position; right, the anatomic defect accounting for the wide displacement of the fracture fragment and its spontaneous reposition upon reduction of the dislocation.

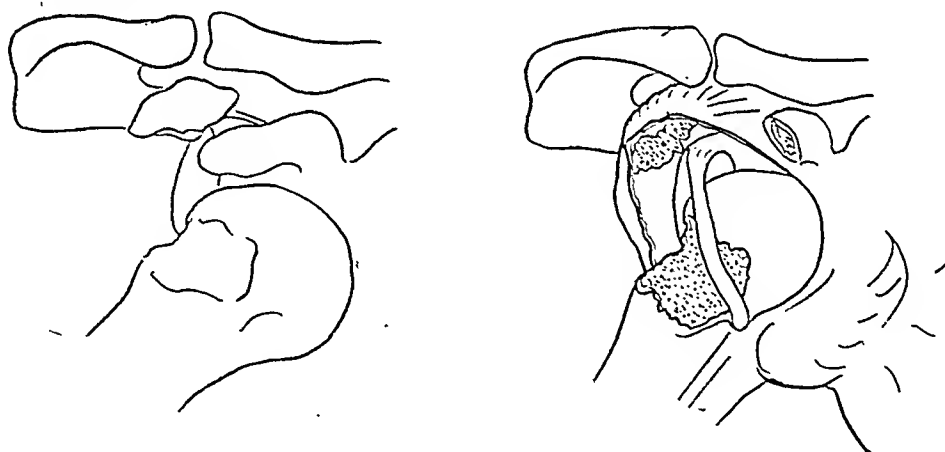


FIG. 2. Left, tracing of x-ray film showing anterior dislocation and fracture of the greater tuberosity. The fracture fragment is retracted well up under the acromion; right, the anatomic equivalent of a massive avulsion of the intrinsic tendons from the humerus accounts for this phenomenon and for the failure of fracture reposition to occur when the dislocation is reduced. Early operative repair is indicated.

the humerus has dislocated. (Fig. 1.) Under these conditions reduction of the dislocation results in spontaneous anatomical reposition of the tuberosity fragment which then may be disregarded completely during aftercare of the case. Occasionally the tuberosity fragment is seen to be retracted up under the acromion. (Fig. 2.)

Occasionally the tuberosity fragment accompanies the humeral head. (Fig. 3A and B.) Such a lesion rarely is characterized by spontaneous accurate replacement of the fracture fragment following reduction of the dislocation. Intrinsic tendon damage usually is present and should be repaired as soon as significant symptoms and disability

prove persistent. Intrinsic tendon damage is the lesion most commonly encountered in dislocations whose post-reduction courses are painful and prolonged. Occasionally a large tuberosity fragment extends forward to involve the bicipital groove.

of the humerus is an uncommon but dangerous complication. The risk of serious brachial plexus damage is always present and a single unguarded motion or ill advised forceful manipulation may produce a permanently crippled extremity. Closed

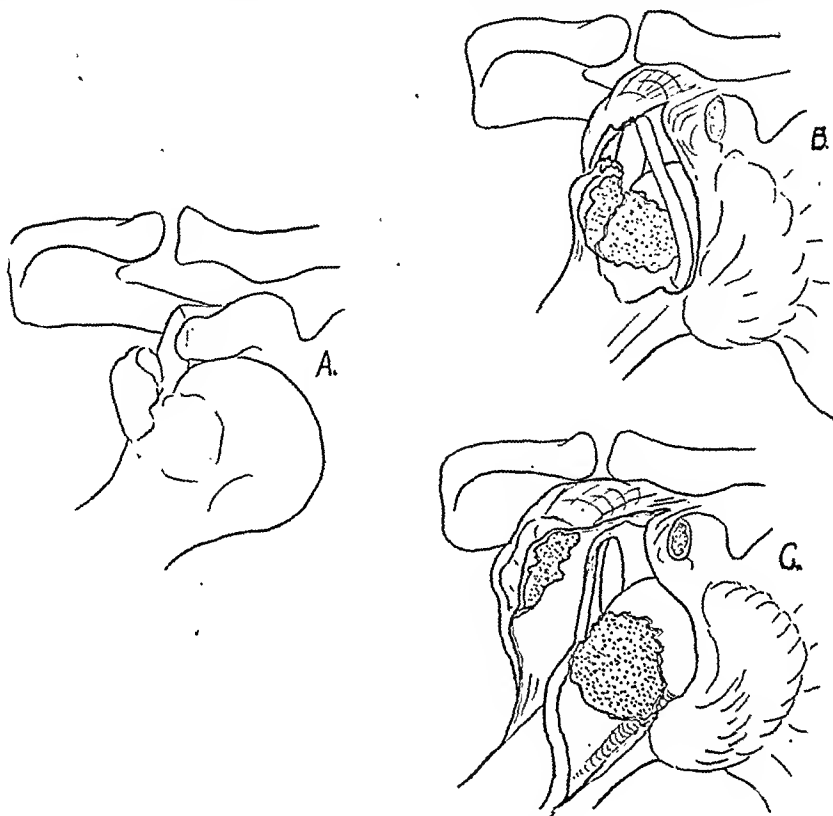


FIG. 3. A, tracing of x-ray film showing anterior dislocation and fracture of the greater tuberosity. The fracture fragment has accompanied the humeral head into its dislocated position; B, the anatomic defect frequently accounts for the position of the tuberosity fragment in A., i.e., a partial or complete avulsion of the cuff fibers from the fragment. This lesion should be suspected whenever reduction of the dislocation is not accompanied by accurate reduction of the fracture; C, when the tuberosity fracture involves the bicipital groove the biceps tendon may slip backwards to assume a position behind the humeral head, very effectively preventing closed reduction of the dislocation.

When this occurs the biceps tendon may slip backward from the groove and come to occupy a position behind the dislocated humeral head, very effectively preventing reduction. (Fig. 3c.) Failure to reduce, or persistent re-dislocation immediately following reduction should warrant early exploration and replacement of the biceps tendon. Repeated closed reductions or unsuccessful attempts to reduce are strongly contraindicated.

*Fracture of the Humeral Head or Neck.*  
Fracture of the surgical or anatomical neck

methods of reduction designed to reduce both the fracture and the dislocation are often unsuccessful. Operation with reduction or excision of the head fragment carried out under direct vision is the therapy of choice when gentle manipulation fails to provide satisfactory restoration of anatomy.<sup>8</sup>

*Reduction of Uncomplicated Dislocation at the Shoulder.*<sup>11</sup> The so-called "heel in the axilla" maneuver for reduction of anterior dislocations of the shoulder is to be strongly condemned. It is neither safe nor



necessary for use as a routine procedure. The "Kocher" maneuver as it is generally used has become a manipulative procedure designed to force the humeral head back into the glenoid fossa. In late reductions when the glenoid cavity is partially filled by blood clot and the surrounding musculature has lost its normal elasticity such a procedure may be warranted as the only method for obtaining a closed reduction. In early lesions the procedure is unnecessary and potentially dangerous.

The safest and most efficient method of reduction consists of steady traction in the axis of the adducted humerus under adequate anesthesia. Countertraction by gravity or a thoracic swathe may be required. If the traction is steady, the majority of dislocations reduce without further manipulation within sixty seconds. When this fails to occur traction should be continued for several additional minutes after which a gentle rotary motion of the humeral shaft or a lateral push against the displaced humeral head almost always will be followed by restoration of anatomy. This method of reduction is not only safe but will be successful in all early cases adequately anesthetized unless there exists an unrecognized complicating factor which precludes reduction by closed methods.

*After-treatment.* Once reduction is accomplished optimum after-care must provide: (1) protection against re-dislocation (2) comfort and (3) maintenance of function. Usually the discomfort is minor in degree. Maintenance of motion and function is always possible without undue risk of redislocation. The speed and degree with which function may safely be resumed depend upon the ease of the reduction. The more rapidly and easily a dislocation is reduced the more easily will it re-dislocate and vice versa. Re-dislocation, however, becomes a significant danger only when the arm is elevated against gravity. Normal progressive use of the arm in the dependent position is possible and safe from the start. A safe equivalent of motion in the elevated position can be maintained by a program

of gravity-free pendulum exercises done in the stooped position. A sling and swathe is adequate protection against re-dislocating forces of external origin. This should be worn while sleeping for at least a month. With a responsible cooperative patient the dressing may be left off during the day at all times when he can voluntarily refrain from active elevation. Strenuous activities even with the arm dependent should be restricted for several weeks. The average case may be allowed use of the arm in all positions below 45 degrees of abduction throughout the first two weeks and below 90 degrees throughout the second two weeks. Progressive resumption of use in all elevated positions is then safe. In irresponsible or uncooperative patients the arm should be dressed in a sling and swathe for at least several weeks and the penalties of such restriction of motion (prolonged but not usually permanent stiffness) accepted as unavoidable. Healing takes place or not regardless of the type of treatment provided re-injury is prevented. Habitual dislocation results from re-injury or specific intrinsic damage and is otherwise unrelated to the treatment of the primary lesion.

#### INTERNAL DERANGEMENT OF THE SUBACROMIAL MECHANISM

The subacromial mechanism is bounded above by the acromion and the coracoacromial ligament and below by the head of the humerus. Its component structures include the subacromial or subdeltoid bursa, the musculotendinous cuff, the articular capsule of the shoulder joint and some loose areolar tissue. The intra-articular portion of the long biceps tendon, although functionally unassociated, is in close proximity to these structures and is to be considered as a potential etiological factor in the production of subacromial derangement.

All subacromial lesions are prone to involve secondarily the subdeltoid bursa and produce the clinical syndrome generally recognized and treated as "subdeltoid or subacromial bursitis." The almost universal acceptance of this term



as the diagnosis upon which therapy is to be based constitutes the most important single factor mitigating against successful management of the painful or stiff shoulder. "Bursitis," as an all inclusive term denoting the diagnosis and basis for therapy in the painful shoulder, is as irrational as would be peritonitis for pain in the abdomen. Both are clinical syndromes resulting secondarily from some primary focus of irritation. Rational therapy demands identification and management of the primary lesion.

### 1. *Differential Diagnosis of Painful and/or Stiffened Shoulder*

#### 1. Intrinsic lesions affecting the sub-acromial mechanism:

- (A) Calcific deposit in the short rotator tendons
- (B) Adhesive capsulitis (idiopathic frozen shoulder)
- (C) Rupture of the musculotendinous cuff
- (D) Arthritic changes in acromion and humerus
- (E) Infection, originating in the bursa
- (F) Rheumatoid arthritis involving the bursa

#### 11. *Extrinsic Lesions Simulating Bursitis but Usually Affecting the Shoulder Joint Mechanism*

- (A) Disuse due to any cause
- (B) Internal derangement of the acromioclavicular joint
- (C) Neurological lesions of cervical or peripheral nerve origin
- (D) Adjacent infection (bone or joint)
- (E) Bone neoplasm (usually humerus)
- (F) Rheumatoid arthritis
- (G) The formation of adhesions, post-traumatic

#### CALCIFIC DEPOSITS IN THE SHORT ROTATOR TENDONS<sup>1,3,4,5,6,8</sup>

*Diagnosis.* Subdeltoid bursitis secondary to inflammation centered around a

calcific deposit accounts for approximately two out of every three painful shoulders encountered in the United States. Adequate x-ray films demonstrate the presence, location, size and consistency of the deposits. Similar quiescent deposits are to be encountered frequently in x-ray films of asymptomatic shoulders. The diagnosis, therefore, cannot be made upon the basis of x-ray evidence alone.

Little difficulty is to be encountered in identification of the acute case. In addition to the x-ray findings there is constant and severe pain in the shoulder, aggravated by motion and little relieved by rest. There is wincing tenderness over the bursa which may be swollen and even fluctuant, and this is exquisite at the site of the inflamed deposit. A mild systemic reaction may be present and the effects of pain and loss of sleep usually are obvious in the patient's face. Clinically the acute lesion requires differentiation only from acute infection and recent trauma. The history usually excludes the latter while the former is ruled out by the great disparity between the severity of the local reaction and the relative mildness of the systemic response.

The chronic lesion may be much more difficult to identify with certainty due to the frequency with which incidental quiescent deposits are encountered in x-rays of non-painful shoulders. It may be assumed with reasonable certainty that if a deposit is present by x-ray there is little or no possibility that the tendon cuff is ruptured. Several hundred operations for removal of calcific deposits and a similar number of cuff tears repaired by operative means disclosed only one patient to have both lesions simultaneously. The remainder of the lesions to be differentiated should be excluded prior to deciding that the deposit seen by x-ray is the cause of a chronic painful shoulder. In the appropriate age groups early bone neoplasm should be suspected in any case which responds abnormally or fails to respond to routine sedative measures over a protracted period. A secondary syndrome resulting from

chronic muscle spasm is common in the chronic case of more than a few weeks' duration. As a result, the insertion of the deltoid may be described as the subjective center of pain. Radiating pain is common in the arm, forearm and even the fingers and often involves the posterior scapular muscles and the trapezius. As a result of constant pain, stiffness and atrophy, the penalties of disuse eventually become superimposed to further complicate the diagnostic problem.

*Treatment.* Rational treatment of the calcific lesion depends upon comprehension of the following: (1) Eventual spontaneous cure is to be expected regardless of the type, presence or absence of therapy since the disease is self-limiting. (2) Only two types of treatment are available, curative and palliative. Removal of the deposit by operation or aspiration are the only known therapies of proven curative value. All others are purely palliative in nature or empirical in effect. Less than 10 per cent of chronic cases require curative treatment. The remainder are controllable by palliative measures until spontaneous remission or subsidence of symptoms occurs. The only indication for curative treatment in the chronic case consists of symptoms and disability sufficient to make it worth while from the patient's point of view. The patient alone is qualified to decide this point. The only certain curative therapy available for the chronic lesion is removal of the deposit by operation. Rarely is it amenable to aspiration through a needle and there is little or no likelihood of a favorable response to radiotherapy. Palliative therapy includes all sedative measures which reduce pain and muscle spasm. Every effort should be made to maintain the mobility of the arm. Rest or restriction of motion is strongly contraindicated in the chronic case since the inevitable penalty is increased atrophy and stiffness of the shoulder mechanism. Simple home measures such as gentle local heat, aspirin and barbiturates, coincident with frequent active exercises within pain limits are

found to accomplish just as much as any of the more widely publicized formal therapies.

In the acute lesion, although the duration of symptoms rarely exceeds seven to ten days under any circumstances, the pain often is severe enough to demand curative therapy. In the presence of acute inflammation the contents of the deposit become infiltrated with exudate and not only change from a dry to a semi-fluid consistency but also develop considerable tension within a closed cavity. Following localization of the lesion by x-ray and palpation the treatment of choice is puncture and deflation of the tense deposit by a needle inserted under procaine hydrochloride anesthesia. Some of the material should be aspirated as proof of the successful accomplishment of this objective. The therapeutic principle is identical to that underlying incision and drainage of an abscess. Once the contents of the deposit are allowed to escape from their tendon cavity into that of the bursa rapid absorption and subsidence of the inflammatory reaction is the rule. When this procedure is impractical or unsuccessful operative incision of the deposit may be warranted. The results of radiotherapy, while frequently spectacular, are empirical and similar to the results of adequate local sedation by any other means.

#### RUPTURE OF THE MUSCULOTENDINOUS CUFF<sup>2,3,7,8,9,10</sup>

Traumatic lesions of the cuff may vary from a rupture of only a few fibers to a complete avulsion of its whole insertion from the humerus. They are classified as complete or incomplete depending upon whether the tear involves the whole or only a partial thickness of the tendon cuff. The diagnostic and therapeutic significance of a cuff injury depends not upon its presence but upon its effect. A large tear may produce insignificant pain and disability while a small lesion may prove extremely painful and completely disabling to the individual.

Exploration is the only certain method for making the diagnosis of incomplete rupture of the cuff. There are four tests for the certain identification of a complete thickness tear. Often none of these tests will be positive in the case at hand and their absence does not rule out the lesion.

1. *By x-ray:* The presence of a retracted fracture of either humeral tuberosity is pathognomonic of a large tear. (Fig. 2.)

2. *By x-ray:* Demonstration of an abnormal communication between the shoulder joint and bursal cavities by the injection of contrast media, e.g., filtered oxygen, makes the diagnosis reasonably certain.

3. *By palpation:* A hiatus in the continuity of the tendon fibers usually is demonstrable by expert and experienced palpation. This test is valid only in the chronic lesion and almost always is precluded by the presence of acute tenderness.

4. *By the demonstration of a function or dysfunction* of the injured segment of the tendon cuff: One of the important functions of the intrinsic cuff is to stabilize the glenohumeral fulcrum so that the deltoid can maintain the extremity in the abducted position against gravity. Without cuff function the deltoid is powerless. The main duty of carrying out this particular function falls upon that segment of the cuff directly overlying the humeral head, i.e., that portion of the cuff having a mechanical advantage to abduct. The remainder of the cuff is relatively unrelated to the maintenance of abduction. Depending upon the rotation of the arm any of the four tendon components of the cuff mechanism may assume a position directly above the humeral head and be called upon to fulfill this functional demand. It is found that cases characterized by a complete avulsion of the cuff from the humerus are unable to maintain abduction in any position. On the other hand tears less than 3 cm. in length are compensated for by adjacent intact tendon fibers so that no serious functional defect may be apparent except for a relative weakness as compared to normal. Intermediate tears demonstrate inability to

maintain abduction when the arm is placed in a position which throws the load upon the torn segment. Maintenance of abduction against gravity or light pressure, therefore, should be tested with the arm passively abducted to the horizontal position and successively placed in all positions of rotation. This test is invalidated by acute pain which often prevents maintenance of abduction even though the cuff be intact, and its results cannot be depended upon for the certain diagnosis of lesions less than 3 cm. in length.

The clinical picture of a cuff tear is characterized by some combination of many other confirmatory signs and symptoms which have been described with great clarity by Codman.<sup>3</sup> It is to be emphasized, however, that all manifestations of the lesion other than the four described above are frequently reproduced by other conditions and not to be considered as pathognomonic. Passive restriction of glenohumeral motion, except when produced by pain, may be taken as reasonably certain evidence against the presence of a complete tear. No frozen shoulder explored to date has been the seat of a gross cuff tear (although a few incomplete tears have been found in stiff shoulders), and none of a large series of complete tears proved by operation has been characterized by stiffness. A calcific deposit or stiffness, therefore, makes the possibility of rupture remote.

A definitive diagnosis of cuff tear is neither necessary nor important to the choice of therapy except in the case of massive avulsions, all of which are disabling and warrant surgical repair at the earliest possible moment. All suspected lesions should receive at least three weeks' observation and conservative therapy of a sedative nature. The use of an abduction splint during this time does more harm than good and is strongly contraindicated. Symptoms subside and function returns spontaneously within two to three weeks following injury in the majority of cases. As long as improvement continues, no matter how slowly, conservatism is indi-

cated. There is only one indication for exploration and operative repair. This consists of symptoms or disability sufficient to make it worth while from the patient's point of view. This indication is valid regardless of whether or not a defini-

complete recovery within two weeks under such a regimen. Many cases characterized by definitive evidence pointing to the presence of a tear also are characterized by spontaneous subsidence of symptoms and recovery of function. Those with

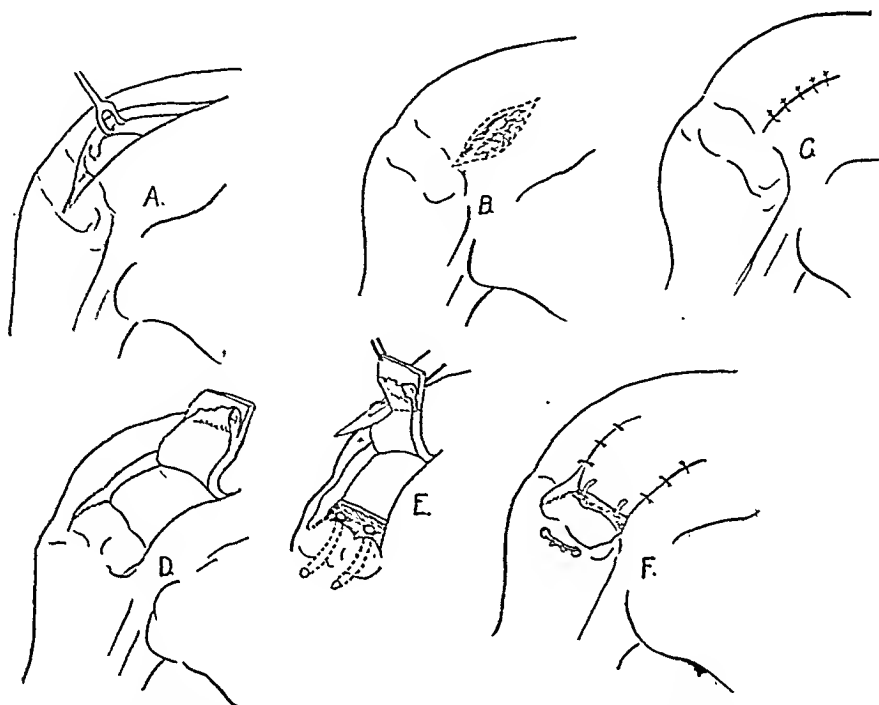


FIG. 4. A, identification of a deep surface tear through an incision in line with the cuff fibers; B, localized area of laceration visualized on the presenting surface of the tendon cuff. Dotted line indicates placement of elliptical excision; C, side-to-side suture of the elliptical defect following excision of B; D, following identification of a deep surface tear as in A, a flap of cuff as wide as the tear is long is elevated from the humeral attachment of the cuff; E, the tear is excised; F, the shortened flap is reinserted into a bony trench in the humeral head and fastened by a mattress suture passed through drill holes in the bone and tied lateral to the greater tuberosity.

tive diagnosis can be made. It is to be emphasized that while the diagnosis may be suspected it cannot be made with certainty in many complete thickness tears nor in any incomplete tear. Often a suspected anatomic diagnosis is confirmable only by exploration.

**Treatment.** Conservative therapy is indicated in the great majority of cases for at least several weeks. It should provide: (1) comfort, (2) protection against additional damage and (3) maintenance of function up to the limits of pain and fatigue. A therapeutic program identical to that described for fractures of the upper humerus not requiring reduction is optimum. The great majority of suspected lesions make a

persistent residual pain or disability warrant consideration of operative therapy regardless of the presence or absence of a definite diagnosis.

**Operative Repair.** Adequate exposure is of paramount importance to the success of any operative repair. The deltoid muscle may be split downward from the acromion at any point so long as the split does not extend distalward for more than 3 cm. When a longer muscle incision is necessary it should never be made except at the anterior border of the deltoid or through the deltopectoral interval. A transacromial approach (Fig. 5B) provides the best exposure of the musculotendinous cuff coincident with a good cosmetic result. This

approach utilizes a short anterior deltoid splitting incision which, when necessary for exposure, is carried backward through the acromion process just lateral to the acromioclavicular joint. Excision of the outer fragment of the divided acromion is

into a bony trench at the anatomical neck and fastened in place by heavy mattress sutures through drill holes in the bone. (Fig. 4F.) Visible areas of localized tendon laceration in the floor of the bursa should be removed by an elliptical excision and the

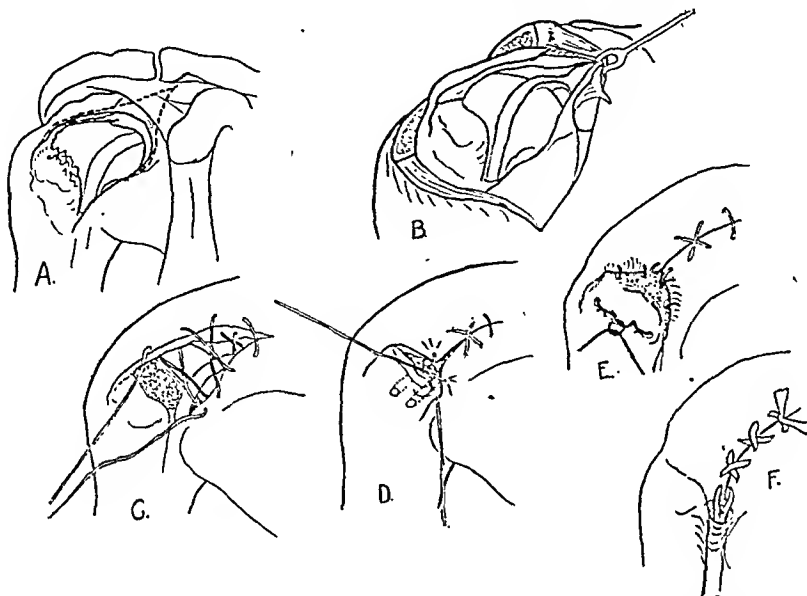


FIG. 5. A, rupture of cuff. Dotted lines indicate lines of incision for removal of damaged tissue in such a way that the residual defect simulates an isosceles triangle; B, exposure of a complete cuff tear through a transacromial approach; C, placement of continuous "shoe lace" suture following triangular excision of the tear. Stippled area indicates the portion of humeral head denuded of cartilage for reinsertion of tendon; D, the suture is pulled tight up to but not past the point of tension with the arm at the side. Drill holes are made through the tuberosity to emerge close to the transposed ends of the tendon flaps; E, additional mattress sutures are required to stabilize the residual edges of the tendon flaps in many tears of 3 cm. or more; F, small tears close to the bicipital groove may be obliterated by autogenous suture using the split intra-articular portion of the biceps tendon which has first been separated from its glenoid attachment.

carried out routinely at the close of the operation in preference to repair of the bone incision.

**Incomplete Ruptures.** Incomplete thickness tears often remain obscure at operation since if they involve the deep surface of the cuff the floor of the bursa remains intact. This type of tear requires for identification a longitudinal incision through the cuff fibers so that the deep tendon surface may be visualized. (Fig. 4A.) Following identification a flap of cuff insertion as wide as the tear is long should be elevated from the humerus. (Fig. 4D.) The torn portion is excised (Fig. 4E) and the flap reinserted

defect repaired side-to-side. (Fig. 4B and C.) In neither repair should there be any appreciable tension upon the reparative sutures and following wound healing the postoperative program may approximate that described for the treatment of upper humerus fractures not requiring reduction.

**Complete Ruptures.** Since no two tears ever are identical no standardized reparative technic is possible. However, every repair to be successful should provide: (1) restoration of continuity between the intrinsic muscle bellies and the humerus and (2) snug apposition of healthy to healthy tissue without tension at the repair

site. End-to-end or end-to-bone repair rarely is possible in such a way that these prerequisites are fulfilled and the majority of attempts to do so are failures. Follow-up analyses of fractured upper humeri have demonstrated beyond all doubt that the direction, length and point of insertion of any component of the cuff can be altered grossly without detracting from the total function of the shoulder mechanism. The two prerequisites essential to success mentioned above therefore should be fulfilled, if necessary at the expense of normal anatomy. As a general plan of procedure applicable to the majority of complete lesions the edges of the tear are excised back to healthy vascular tissue in such a fashion that the residual defect becomes an isosceles triangle with the greater tuberosity as its base. (Fig. 5A.) The longer the sides of this triangle the easier is the subsequent repair. A continuous shoelace type of heavy suture is implanted in a manner to provide side-to-side apposition of the sides of the triangle (Fig. 5C), up to but not past the point of tension with the arm at the side. The underlying humeral head is denuded of cartilage at the point where side-to-side apposition creates tension upon the suture. (Fig. 5D.) The suture ends then are passed through drill holes in the bone and tied lateral to the tuberosity. Ruptures up to 2 cm. in length can be obliterated completely by this technic. Larger lesions usually require the utilization of additional mattress sutures (Fig. 5E) for stabilization of the residual tendon edges. Certain small tears situated in close proximity to the bicipital groove are amenable to repair by autogenous suture using the split intra-articular portion of the biceps tendon. The tendon is divided at its glenoid attachment and split longitudinally down to the upper end of the bicipital groove. The two halves are then woven, shoelace fashion, through the edges of the tendon defect and tied as in Figure 5F.

Certain massive tears are not amenable to triangular excision and side-to-side repair. End-to-bone repair then becomes

mandatory. It is a mistake to attempt reapproximation of the avulsed tendon insertions to the greater tuberosity at a cost of tension. They should be reinserted into the humerus at whatever point they will reach without tension in any manner restoring continuity between the intrinsic muscle bellies and the humerus.

An abduction splint is unnecessary and potentially disadvantageous to the post-operative regimen providing repair has been carried out according to the principles and technic described. Gravity-free motion and function should be commenced as soon as the operative wound has healed, and gradually but progressively increased. Motion and use against gravity should be restricted until such time as seems compatible with solid healing of the repair. The results<sup>9</sup> are very satisfactory.

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# PRESENT CONCEPTS CONCERNING THE CARE OF THE BURNED PATIENT\*

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**B**ECAUSE significant changes have occurred in the treatment of thermal injuries over the past five years, it seemed desirable to review briefly some of the more recent trends and outline a method of treating burns which has been found to be satisfactory. The treatment of patients with burns can be divided into the following four main categories: 1. The early therapy consisting of the relief of pain and treatment of shock; 2. the immediate care of the local wound and the control of infection; 3. the nutritional and metabolic problems of the burned patient and 4. skin grafting and the prevention of scars and contractures.

## EARLY TREATMENT

Immediate treatment of burns should consist of instituting shock therapy as soon as possible and general anesthesia should be avoided. Experimental studies by Elman<sup>1</sup> demonstrated that the mortality rate is definitely increased following the administration of barbiturates and morphine while clinical experience has shown that such compounds should be employed cautiously and only when necessary. Since relief of pain helps alleviate shock some medication for this purpose should be beneficial. Because the circulation is frequently impaired following a burn or injury, morphine given subcutaneously or intramuscularly is often not absorbed and therefore does not relieve pain.<sup>2</sup> Repeated injections may later be absorbed when the circulation has been restored to normal with a resulting morphine poisoning.<sup>3</sup> Because of this, Beecher<sup>2,3</sup> advises giving morphine sulphate, grains  $\frac{1}{6}$  intravenously to adults

and repeating every half hour or so if necessary.

The intravenous administration of 0.1 to 0.2 per cent procaine has been employed for the relief of pain and while there has been little experience with this method, it may offer a suitable way of relieving the discomfort while shock therapy is being carried out. Gordan<sup>4</sup> advises injecting 1 Gm. of novocain crystals in 500 to 1000 cc. of an isotonic salt solution over a period of one to one and one-half hours.

During the past ten years the treatment of shock in burned patients has been largely accomplished by the use of plasma. In the past few years it has been noted both experimentally<sup>5,6</sup> and clinically<sup>7-10</sup> that the use of a sodium containing electrolyte solution and blood is just as effective as plasma and in some respects is preferable. Plasma was advocated primarily because of the osmotic effect of the protein molecule and also because it reduces the existing hemoconcentration. However, it has been demonstrated that there is some reduction in the red cell mass following a burn<sup>11,12</sup> and that hemoconcentration can be overcome and an adequate circulating blood volume maintained if electrolyte solutions are employed.<sup>5-7</sup> Plasma proteins have been shown to be lost from the vascular system at a rate comparable to that of sodium following a burn.<sup>13</sup> Thus, the more recent trend has been toward supplying blood which contains both red cell and protein elements and to maintain the circulation by increasing tissue tension by the administration of an electrolyte solution. In a series of patients treated with large amounts of plasma the edema in the burned

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areas remained for longer periods of time than it did in those patients treated with an electrolyte solution and blood. This probably occurred because of the presence of relatively large amounts of protein in the extravascular spaces of the traumatized area in the plasma treated patients.

Various solutions have been demonstrated to be effective in combating shock<sup>5,7,9,10,14,15</sup> but we prefer a solution which contains inorganic electrolytes in amounts similar to that found in the extracellular fluid. Since additional water should be provided so that good kidney function will occur, such a solution has been administered after diluting it to two-thirds the original strength. Hartman's solution (Ringer-lactate) can be used or one containing 6 Gm. of sodium chloride and  $2\frac{1}{2}$  Gm. of sodium bicarbonate per liter. In order to make the latter two solutions hypotonic, 500 cc. of water should be added to 1,000 cc. of an isotonic solution. In many instances the patient will be able to drink this mixture but if it cannot be taken orally due to nausea or vomiting or if it seems that the burn is sufficiently severe so that vomiting might occur, it is wise to administer the solution intravenously until the patient's condition improves.

Since the hematocrit and various other chemical constituents often fail to indicate the amount and type of treatment necessary,<sup>7,16,17</sup> the latter should be governed by the severity of the burn and the size of the individual patient. The extent of the body surface area burned can be determined from the charts advocated by Lund and Browder.<sup>18</sup> The amounts of hypotonic electrolyte solution and blood which have been found to be effective are shown in Table 1.

No hard and fast rule should be used in prescribing therapy but the amounts of the various solutions should be altered to fit the patient's individual requirements and his response to treatment. The authors,<sup>7</sup> as well as others<sup>9</sup> have found that the urinary output provides a valuable guide as to the state of the patient and the effec-

tiveness of therapy. In order that frequent checks can be made it is often desirable to insert a Foley catheter into the bladder of patients with a moderate or severe burn. The urine is then collected into a large graduated cylinder so that the per minute

TABLE I  
THE AMOUNT OF 0.6 PHYSIOLOGICAL ELECTROLYTE  
SOLUTION AND WHOLE BLOOD TO BE USED IN  
COMBATING SHOCK RESULTING FROM A BURN

Per Cent of Body Surface Burned	The Amount of Hypotonic Electrolyte Solution Given in the First Twenty-four Hours	Amount of Blood Given during First Twenty-four Hours
5 to 15	Amount equal to 6 to 8% of patient's body weight	25 to 50 cc. for every per cent the body is burned or an amount equal to
15 to 35	8 to 12% of body weight	2 to 6% of body weight; (the larger quantities to
35 to 100	12 to 14% of body weight	be given to patients with third degree burns)

rate of urinary flow can be frequently and easily calculated.

When the inhalation of smoke and fumes has occurred it would seem wise to inject an isotonic electrolyte solution into the burned area as advocated by Berman and his co-workers.<sup>15,19</sup> By such a method, tissue tension is increased with a preservation of a normal blood pressure and pulmonary edema is less likely to occur. The amount of whole blood employed should vary somewhat depending on the age of the person, the extent and depth of the burn and the patient's cardiovascular status. Smaller amounts of blood should be given to patients with first and second degree burns and somewhat larger quantities employed when third degree burns are present, since more red cells are destroyed or lost in patients with third degree burns. The red cells are not only destroyed initially with heat but are subsequently trapped in the capillaries in the injured area. Because



of a persistent negative nitrogen balance, the presence of infection, the oozing of blood from granulating surfaces and the opening up of new capillaries during healing the patient with a third degree burn requires large amounts of blood initially and often again after the first two to four weeks. It is well to give smaller amounts of morphine, blood and electrolyte solution when treating small individuals or infants and the quantities employed should be governed by the patient's size and the severity of the injury.

#### LOCAL WOUND THERAPY

Many of the older and more widely employed methods of caring for burned areas have certain disadvantages. Bettman<sup>20</sup> recently reported a 3.1 per cent mortality rate in over 700 patients on whom tannic acid and silver nitrate were used. It was also evident from this study that liver necrosis did not cause death in any of the patients who succumbed; however, it has been shown both clinically<sup>21,22</sup> and experimentally<sup>23</sup> that the use of tannic acid and other chemical eschar producing substances causes local injury to tissues. Thus, when such methods are used it is conceivable that a deep, second degree area might be converted into a third degree burn or that harmful systemic changes may occur. In most instances death due to liver necrosis occurred following a burn when tannic acid jelly was employed or when the patient was put in a bath containing a tannic acid solution.<sup>24,25</sup> However, Saltonstall, Walker, Rhoads and Lee<sup>26</sup> demonstrated by liver function tests that the chemical eschar producing substances usually cause some impairment to liver function, although in many instances it was not severe enough to cause death.

Since more recent studies<sup>27-29</sup> have provided methods which have all the advantages of the chemical eschar methods without their local and systemic ill effects, the use of tannic acid is contraindicated in the treatment of thermal injuries. It has also been emphasized that toxic systemic

effects may occur in patients who have had boric acid applied to the burned area or a crystalline sulfonamide compound used as a dusting powder or used in a water soluble ointment base. Since there is little evidence to indicate that the sulfonamides are advantageous when applied locally they are best avoided. The oral administration of the various sulfonamide compounds should not be instituted until an adequate volume of urine is being excreted. Penicillin can be injected safely and should be employed when infection is likely to occur.

In 1942, Allen and Koch<sup>27</sup> described the use of the occlusive or pressure dressing technic. If such dressings are used, vaseline or carbowax is placed over the burned area, followed by layers of sterile gauze dressings, mechanic's waste and an elastic ace bandage or flannel cut on the bias. Although this method had some advantages over the older forms of treatment and has been employed widely during the past few years, it is not entirely satisfactory. First, it is obvious that effective pressure cannot be employed on the head, neck, thorax, or abdomen and thus in these regions the dressings act merely as a sterile covering. When they are applied to the head and neck contamination often occurs due to vomiting or excessive salivation and when they are used on the chest interference with pulmonary ventilation may result. Secondly, application of pressure dressings are often very time-consuming and cumbersome and the patient experiences a certain amount of discomfort when the dressings are changed. Protein, salts and fluid continue to seep into the dressing, not only causing a loss of these constituents but also providing desirable media for bacteria as well as a rather unpleasant odor. In some patients an unexplained fever necessitates removal of the dressing so that the wound can be inspected and the presence or absence of infection determined.

Chase<sup>28</sup> has devised a protein extract from the beef aorta which when applied to the burned area produces an eschar which has no apparent local or systemic

injurious effects. He has employed this technic in several hundred ambulatory patients and more recently Zyla and Weller<sup>30</sup> have used it in more than 400 seriously burned patients and have found it to be quite satisfactory. This protein extract can be applied in ointment form directly to the burned area or it can be put on fine mesh gauze which is then laid over the injured region.

Experience obtained during the war indicated that extensive washing and débridement of the burned area was not necessary. Chase<sup>28</sup> as well as Zyla and Weller<sup>30</sup> have employed a germicidal detergent which is first sprayed over the burned area and followed by a normal saline solution. These workers advocated using the protein extract either in the so-called open method or closed method. In the open method the protein extract is applied to the burned area and the patient is placed on a Bradford frame under a heat tent. Subsequently, if the eschar cracks, more ointment can be applied. In the closed method the ointment is covered by a fine mesh gauze and the region wrapped with a sterile dressing. If infection occurs, the eschar which is produced liquifies. The wound can be frequently inspected when either the open or closed methods are employed without fear of introducing further infection.

More recently, Howes and Ackermann<sup>29</sup> reported a technic for treating the local wound which appears to be sound and especially advantageous in patients with third degree burns. It is efficient, simple, nontoxic and apparently accelerates the separation of the dead tissue resulting from a third degree burn.

#### NUTRITIONAL AND METABOLIC PROBLEMS OF THE BURNED PATIENT

The nutritional problem of the burned patient has been discussed elsewhere.<sup>31</sup> Briefly, the patient should receive a diet equal to 1.6 times his basal caloric requirement. Twenty per cent of the total caloric intake should be derived from protein.

Burned and injured patients should be given a vitamin intake ranging from five to ten times their normal daily requirement.<sup>32</sup> This is especially true of vitamin C and B complex. In patients with mild burns, food can be taken on the day of injury but in those patients with moderate or severe burns it is best to start the oral intake of food on the second or third day. After five to fifteen days the total caloric intake and the amount of protein can be gradually increased as the patient tolerates the food. During the convalescence period the patient by choice drinks large quantities of fluid.<sup>7</sup> Experimental studies<sup>33</sup> and the aforementioned clinical observations indicate that fairly large amounts of water are retained by the body. Thus, after three days the low plasma or serum electrolyte values which are often encountered usually do not indicate a deficiency of these products if adequate shock therapy has been given but result from the retention of abnormal amounts of water. After the first or second day, the intake of large amounts of sodium-containing solutions is best avoided. We have employed a concentrated plasma or albumin solution or a small amount of hypertonic electrolyte solution to promote diuresis and overcome the existing dilution. In extensive third degree burns, it is desirable to increase the oral intake of salt and protein when the necrotic tissue begins to separate and administer blood to prevent or combat anemia and hypoproteinemia.

#### SKIN GRAFTING AND PREVENTION OF SCARS AND CONTRACTURES

Grafting of third degree burned areas should be carried out as soon as possible. The dermatome method described by Padgett<sup>34</sup> has been found to be satisfactory by most workers. Many of the metabolic changes that occur can be avoided or the duration of these alterations shortened if grafting is carried out promptly. The hazard of infection is also minimized when the unhealed areas are reduced in size. The removal of dead tissue by the application of

pyruvic acid paste as advocated by Connor and Harvey<sup>35,36</sup> or the more recent method of Howes and Ackermann,<sup>29</sup> should contribute greatly in reducing the time required for a seriously burned patient to recover and thus minimize infection, metabolic changes, contractures, etc. Occasionally the early excision and grafting of third degree areas is a helpful way of handling these patients.<sup>37</sup>

#### SUMMARY

The treatment of patients with thermal burns can be divided into four main categories and the essential points can be outlined as follows.

1. The treatment of shock should be instituted as early as possible and accomplished by the judicious use of whole blood and an electrolyte solution. The relief of pain in such subjects is best accomplished by the intravenous administration of morphine sulphate, grains  $\frac{1}{8}$  to  $\frac{1}{6}$ .

2. The immediate care of the local wound is best carried out in the following manner: Extensive débridement is not necessary, however, in most patients it is felt that a simple, non-traumatizing irrigation of the area provides some benefit. Following this, either the protein extract advocated by Chase<sup>28</sup> or the ointment advocated by Howes and Ackermann<sup>29</sup> should be applied to the burned area. The systemic administration of penicillin is frequently advantageous for combating infection.

3. The nutritional and metabolic problems can be best summarized as follows: (1) Food is usually omitted (except in those patients with mild burns) for twenty-four to forty-eight hours; (2) a diet containing 1.6 times the patient's basal caloric requirements is then given. Twenty per cent of this diet should consist of a nutritionally adequate protein; (3) after five to fifteen days the diet is gradually increased as it is tolerated so that it will provide adult patients with around 3,000 calories and from 120 to 300 Gm. of protein daily; (4) patients with moderate or severe burns

should be given approximately ten times the daily requirements of the water-soluble vitamins and an adequate amount of vitamins A and D for at least two weeks; (5) since water retention occurs, especially between the second and fourteenth day following a burn, and leads to a hemodilution, this is best corrected by restricting the total daily fluid intake to 2,000 to 4,000 cc. and administering a concentrated sterile solution of albumin or plasma intravenously and repeating if necessary. The administration of 250 cc. of a hypertonic electrolyte solution (2 to 5 per cent) can also be administered between the third and twelfth days; (6) during the convalescent period whole blood should be given to correct or preferably to prevent anemia or hypoproteinemia (if the hemoglobin is over 16 Gm. per 100 cc. albumin or plasma may be employed).

4. Since the successful care of such patients is dependent on the early healing of wounds, the removal of sloughing tissue and the grafting of skin should be accomplished at the earliest possible date. If adequate therapy is given as soon as possible, preferably in an attempt to prevent shock, malnutrition, infection and a prolonged convalescence from open wounds instead of overcoming these conditions once they exist, the mortality and morbidity rates show continued improvement.

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# ANTIBIOTICS IN THE SURGERY OF TRAUMA\*

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THE industrial surgeon is intensely interested in minimizing the incidence of infection in the injuries which he treats. To this end, various bactericidal and bacteriostatic substances have been poured or sprinkled into wounds. During one era, tincture of iodine was used extensively but the tissues rebelled. Later, it was hoped that the sulfonamides would give us a means of rendering wounds sterile without at the same time inhibiting healing. This hope has proved to be futile. The experience of the medical department of the Army<sup>1</sup> and controlled studies by civilian groups<sup>2</sup> showed that the incidence of infection in all types of wounds was not diminished by the local use of the sulfonamide group of drugs. At the present time, if we are to expect any help from drugs in the prevention and treatment of infected wounds, it must come from the field of the antibiotics—antibacterial substances derived from living organisms. For practical purposes this means penicillin and streptomycin, although tyrothricin and bacitracin will be considered.

It is convenient to discuss contaminated wounds under the following headings: (1) Injuries of soft parts, including intra-abdominal and intrathoracic wounds; (2) compound fractures and (3) burns. These may be potentially infected or may show established infection.

## INJURIES OF THE SOFT PARTS

When a laceration is treated in the emergency room of the Henry Ford Hospital no penicillin (and of course, no sulfonamide) is placed in the wound. Dependence is placed on the usual surgical procedures, cleansing of the surrounding skin with soap and water, irrigation of the wound with generous amounts of salt solution, excision of devitalized tissue,

perfect hemostasis and careful suturing unless the elapsed time indicates that a policy of delayed closure should be followed. When the wound is complicated or extensive and involves, for example, the suturing of tendons and nerves, no antibiotic is used locally but since these patients are usually admitted to the hospital it is common to give systemic penicillin. The usual dose is 12,500 units every three hours by the intramuscular route, although twice or four times this much is frequently administered. The patient will be grateful if the penicillin solution to be injected is matched with an equal quantity of 1 per cent procaine solution. Five days is a reasonable period for such prophylactic treatment.

If one of the serous cavities (peritoneum or thorax) has been entered and contaminated, it is logical to supplement the surgical procedure with the local instillation of 100,000 units of penicillin followed by generous doses of the drug administered by the systemic route.

Three methods have been used in an attempt to avoid the frequent and painful injections which are necessary when penicillin is given intramuscularly. One of these is the continuous intravenous drip. Theoretically, this is ideal because an almost constant blood level can be maintained; however, considerable attention is necessary to keep the constant drip flowing and phlebitis is a frequent complication.

Another method is to suspend the penicillin in a vehicle which inhibits absorption. The most successful mixture is that composed of beeswax and oil (Romansky formula). The available preparations contain 300,000 units per cc., and it has been recommended that this is injected daily in order to provide an adequate blood level. Some observers have found wide vari-

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ability of absorption and excretion of penicillin administered in this manner. For example, Kirby et al.,<sup>3</sup> injected 300,000 units daily into fifty-four patients and found that the assayable levels of penicillin in the blood stream were present for periods varying from four to twenty-eight hours. In 69 per cent of the patients levels were present for no longer than twelve hours and in others the levels were present for sixteen to twenty-eight hours. The subcutaneous route seemed to be preferable to the intramuscular route.

The third alternative route of administration is the oral method. Several commercial preparations are available. The penicillin is mixed with buffers to prevent the deteriorating effect of the gastric juice. The daily oral dose must be approximately five times that of the parenteral dose. Two years ago, Jackson and the author<sup>4</sup> made a study of the absorption of large doses of penicillin administered orally. Fourteen patients were given 600,000 units daily. In eight of these a satisfactory level was demonstrated but half of the patients did not show this level until the fourth day.

From the above comments about the methods of administration it may be concluded that the intermittent intramuscular injection is still the most reliable. It is in the treatment of established infections that penicillin becomes really useful. Even then, it should be remembered that before the days of the sulfonamides and penicillin millions of infections were successfully treated by the fundamental and simple surgical principles which included the employment of rest, heat, incision and drainage. Antibiotic therapy must supplement rather than supplant these measures.

Meleney<sup>5</sup> has recently reported his analysis of 744 patients with surgical infections who were treated with penicillin under the direction of the Committee on Chemotherapy of the National Research Council. The best results were obtained in those patients with furuncles or cellulitis (better than 90 per cent were favorable). In an intermediate position were the infected



FIG. 1. Case 1. Showing extent of third degree burns of thighs (first redressing, two weeks after injury).

soft part wounds and infected operative wounds. Slightly more than 60 per cent of these showed a favorable result. Poor results were obtained in empyema, peritoneal abscess and diffuse peritonitis.

Streptomycin may be tried if cultures show gram-negative organisms or if sensitivity tests indicate that the organism is resistant to penicillin but not to streptomycin. It should constantly be borne in mind that in chronic infections an organism may become penicillin-fast after having been originally sensitive. The dose of streptomycin is 1 to 4 Gm. daily, given intramuscularly in divided doses every three hours.

Tetanus does not respond to the antibiotics. Altemeier<sup>6</sup> reported that no beneficial effect of penicillin on the course of established generalized tetanus was observed in a clinical study of sixteen patients. This is disappointing in view of the fact that penicillin inhibits the tetanus bacillus in the test tube. The difficulty probably lies in the fact that penicillin has no effect on the toxin which is the lethal material. The author recently observed tetanus develop in a severely burned patient who was receiving large doses of penicillin. Evidently, there is no certain prophylactic effect. On the other hand, a number of reports indicate that penicillin is a valuable

FIG. 2.

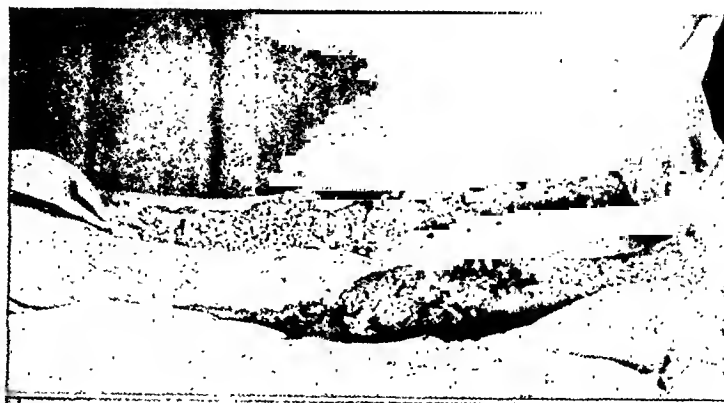


FIG. 3.



FIG. 2. Case 11. Condition of legs on admission. Note ineffectual attempts at skin grafting.

FIG. 3. Case 11. Posterior aspect of legs.

adjunct to orthodox surgery in the treatment of gas gangrene.

#### COMPOUND FRACTURES

As a prophylactic measure against infection in compound fractures, all patients admitted to the Henry Ford Hospital with this injury are given intramuscular penicillin for at least two weeks. An average patient would receive 50,000 units every three hours for the first week and half that dose for the second week. No drug is used locally.

Penicillin therapy is of value if the compound fracture becomes infected and osteomyelitis develops; however, it is in hematogenous osteomyelitis that the drug has given such miraculous results. Altemeier<sup>7</sup> reported on thirty-four patients of whom twenty had positive blood cultures. Seventeen required no surgical intervention while twelve had incision and drainage of soft tissue abscesses and five had incision and

drainage plus osteotomy. No patient required sequestrectomy. There was no death in the series.

With chronic cases of osteomyelitis the results are less satisfying. Of the first nine patients treated at the Henry Ford Hospital only one showed slight improvement. At the present time the method of Coleman and his associates<sup>8</sup> is being evaluated. These authors treated fifty-two bone defects by sequestrectomy followed by packing with bone chips. Penicillin was used locally and systemically. Closure was obtained in 92 per cent of the lesions.

#### BURNS

It is probably unnecessary to give penicillin in the acute phase of a burn. Fever and leukocytosis are constant features of this stage and it is difficult to tell if infection is developing. If there is very high fever, chills, positive blood culture or other good evidence of infection antibiotic treat-



ment should be begun. Penicillin also appears to be especially valuable during the stage of skin grafting.

CASE I. A. McD., a boy, aged eighteen, was admitted on July 9, 1943, following severe flame burns of both thighs, the abdomen, chest and right arm. (Fig. 1.) He was dressed with petrolatum gauze under pressure. After the third degree areas had sloughed, dermatome grafting was begun on August 4th. There was a fairly satisfactory take of the first grafts but there was less and less success with the operations which followed. After eleven stages of grafting there were many granulating areas, including most of the donor areas which had become infected. Culture of the pus yielded *Staphylococcus aureus*, *Staphylococcus albus* and the non-hemolytic streptococcus. Hemoglobin, plasma proteins and vitamin C levels were normal. Following the next stage of Reverdin grafting on December 6th, he was given 100,000 units of intramuscular penicillin daily and the grafts were kept moist with saline solution which contained 100 units of penicillin per cc. The take of these grafts was about 80 per cent, as compared with 5 per cent for the preceding operation. After four more stages of Reverdin grafting he was discharged on March 22nd. Penicillin was almost certainly responsible for the success of the later skin grafting procedures. He received 5,000,000 units intramuscularly and 1,500,000 by local application.

The following case illustrates the possibilities when one is confronted with the problem of a large, neglected burn.

CASE II. G. Z., aged seventeen, was burned on October 20, 1943, when his trousers caught fire while he was handling turpentine. He was admitted to another hospital and tannic acid was applied. On December 15th, and again on February 15, 1944, a few Reverdin grafts were applied. These procedures did little toward covering the large granulating areas. He was transferred to the Henry Ford Hospital on March 23, 1944. The legs were bathed in pus from which was cultured the *Staphylococcus aureus*, non-hemolytic streptococcus and *Bacillus proteus*. The boy was malnourished; there were pressure sores over the sacrum and the anterior superior spines. (Figs. 2 and 3.) He was given penicillin and transfusions and skin grafting was begun in a week. During the next



FIG. 4. Case II. Condition of legs after skin grafting. The depressed scars were subsequently removed.

three months he had ten skin grafting operations. Five of these were of the dermatome variety and five were Reverdin. At the end of this time he was covered with epithelium but had a fibrous ankylosis of the left knee. (Fig. 4.) He received 12,500,000 units of penicillin by the intramuscular route.

Theoretically, streptomycin should be of value when there is pyocyanous infection of the granulating burned surfaces.

#### TYROTHRIN AND BACITRACIN

The author has had little experience with tyrothricin and none with bacitracin. Tyrothricin is the product obtained from *Bacillus brevis* (Dubos) and contains 15 to 20 per cent gramicidin and 40 to 60 per cent tyrocidin. It is effective *in vitro* against the common gram-positive cocci. It is suitable only for topical application. Kozoll et al.,<sup>9</sup> used tyrothricin as a wet dressing in the treatment of seventy-seven patients



with surgical infections, the majority of whom had failed to respond to previous methods of treatment. Twenty cc. of the 2.5 per cent alcoholic solution were added to a liter of distilled water, thus making a solution which contained 0.5 mg. per cc. It was felt that 65 per cent of the patients showed excellent clinical results. They concluded that "Tyrothricin is recommended as a nontoxic, noninjurious antibiotic agent for local use in the treatment of surgical infections, if these meet the following criteria: (a) the wound is open, (b) there is adequate blood supply and (c) the predominant organisms are streptococci or staphylococci or both."

Meleney and Johnson<sup>10</sup> discovered an aerobic gram-positive spore-forming bacillus which produced an antibiotic substance. Because the organism was found in the débrided tissue from the compound fracture in a little girl named Margaret Tracey, the new substance has been named bacitracin. These workers used the material locally in the treatment of one hundred patients with surgical infections, including furuncles, abscesses, infected operative wounds, chronic osteomyelitis and chronic ulcers. It was thought that there was a favorable response in 88 per cent of the patients. Of special interest was the fact that thirty of the strains of cocci encountered were resistant to penicillin but susceptible to bacitracin. This would indicate that the new antibiotic may be of considerable clinical importance, when and if it becomes generally available.

#### SUMMARY

1. The antibiotics have not obviated the need for orthodox surgical procedures in

the prophylaxis and treatment of infected wounds.

2. As valuable adjuvants they have controlled the infection in some patients, and in others they have made possible certain surgical procedures hitherto impossible.

3. Rational treatment demands a full bacteriologic diagnosis of the inhabitants of the wound. This diagnosis must include information about the vulnerability of the organism or organisms to the available antibiotics.

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# AMPUTATION LESSONS FROM THE WAR

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THE civilian or military amputee is faced by a triple threat to his scheme of life by the physical and vocational disability caused by the loss of his limb, by his emotional reaction to his disability and by the attitude of the public toward his defect. His adjustment, therefore, is a challenge to the surgeon's clinical judgment, the limb maker's technical skill and the social conscience of the public. The lack of coordinated effort on the part of these three groups in the past has been responsible for the limited and unsatisfactory adjustments made by many amputees.

The evolution of military care for the amputees in the wars of America was marked in the early days by the limited state of medical knowledge and administrative negligence. The 50,000 men who lost their limbs in the Civil War because of gunshot wounds and hospital gangrene did not have the advantage of modern antibiotics. Nor was the furnishing of artificial limbs considered a proper function of the military organization. For the 4,403 who lost their limbs in World War I only a limited service was provided within the framework of the hospital. The major service was not rendered until discharge from the hospital. It remained for World War II to introduce the concept of rehabilitation in the treatment of the amputee. This was a three dimensional type of service provided at special hospital centers which prepared the amputee for return to society immediately after discharge from the hospital. It contemplated a series of coordinated activities beginning at the time he was hurt and continuing until he was restored to physical and social and in many cases to his previous vocational status.

## PSYCHOLOGICAL PREPARATION

The first step in this plan was that of psychological preparation. The emotional reaction to the loss of a limb varied to a great extent. There were those for whom the injury was a ticket to stateside. For them the war was over. On the other hand, there were many beset with doubts and fears and qualms showing through the thin veneer of bravado. How will my family take it? Will my girl turn me down? Will I ever walk? Will I be able to work? To resolve these anxieties was the responsibility of the medical officer. By reassurance, by demonstration of successful amputees, by the day to day contact with shipmates and buddies with the same type of disabilities, these apprehensions were allayed. But the process and rationale of rehabilitation with its successive steps had to be understood if complete cooperation was to be obtained. Many future problems could be anticipated and eliminated by preliminary briefing, by individual interviews or class discussions. Weekly walking clubs or discussion groups ironed out uncertainties and complaints. The amputee had to be a partner in this enterprise of which he was the beneficiary.

## SURGERY

The second step in the rehabilitation program was the actual surgery of amputations. While the surgical principles and methods of amputation have been more or less standardized over the years, the war experience was a valuable laboratory for the confirmation of those ideas that have withstood the test of time. At the same time it provided an opportunity for the introduction of new methods and



FIG. 1.  
FIG. 1. Stump of Syme's amputation.  
FIG. 2. Below knee amputation.

technics which supplemented the standard procedures.

Conservatism was the keynote. Of more than a million casualties only 18,000 suffered amputation. This was a tribute to the planning of the medical departments. Despite long distances and unfamiliar terrain and in many cases limited supplies the work was carried out with great efficiency. Planning included not only hospital organization and evacuation facilities but also directives for guidance of the surgeon in forward areas concerning indications for amputation, technic, postoperative care and definitive treatment.

*Indications.* Practically all the allied military medical services agreed concerning the indications for amputation. The primary indication was that of loss of blood supply. The second was that of fulminating infection especially gas bacillus infection. The third and less urgent was the instance of severe and irremediable mutilation.

*Open Amputations.* All the allied medical services also agreed on the adoption of the open amputation as the technic of choice in combat areas. However, there was considerable variation in the actual measures employed. The advocates of the classic guillotine amputation adhered rigidly to their formula. But time and again the operation was frequently performed at the site of election instead of the most distal point of viable tissue with consequent loss



FIG. 3. Stokes-Gritti amputation without prosthesis.



FIG. 4. Above the knee amputation.

of valuable bone length following revision of the stump. In the short below the knee amputations this frequently resulted in the loss of the valuable knee mechanism. Furthermore convalescence was unusually

prolonged because of the large open area that had to be covered by gradual contraction of the skin.

Because of these complications the true guillotine amputation was reserved for cases of malignant infection only. In other injuries the open amputations were modified as follows: A circular incision was made through the skin and fascia at the most distal point of viable tissue. The flap was turned back as a complete cuff for about three inches. With a large amputation knife the remaining muscles were cut through as in the true guillotine amputation. The periosteum was incised at the level avoiding the stripping of the bone. The large vessels were doubly ligated with chromic gut, the nerves sharply divided without manipulation or injection and allowed to lie free in the intermuscular planes. The cuff of skin and fascia was then allowed to cover the open end of the stump and skin traction with moleskin strips was applied. By this procedure the healing period was shortened from six to eight weeks to two to three weeks. The skin closed rapidly so that skin grafting or wide excision of the scar at the time of revision was unnecessary.

The aim of the open amputation is to save life and prevent the complication of flap disruption and infection where primary flaps are employed. Certainly the latter technic is contraindicated in a combat zone. In industrial accidents where unclean conditions obtain the same principles hold true.

*Definitive Treatment.* However the aim of the final operation whether by plastic repair of the stump, revision or reamputation, is to obtain the best possible stump and one of optimum length, or a shape that allows it to be fitted properly with an artificial limb and a terminal scar so placed that it is away from the pressure of the artificial limb bucket. The skin should be supple and not adherent to the bone.

The experience of the military services in all the countries agreed on the employment of a limited number of standard

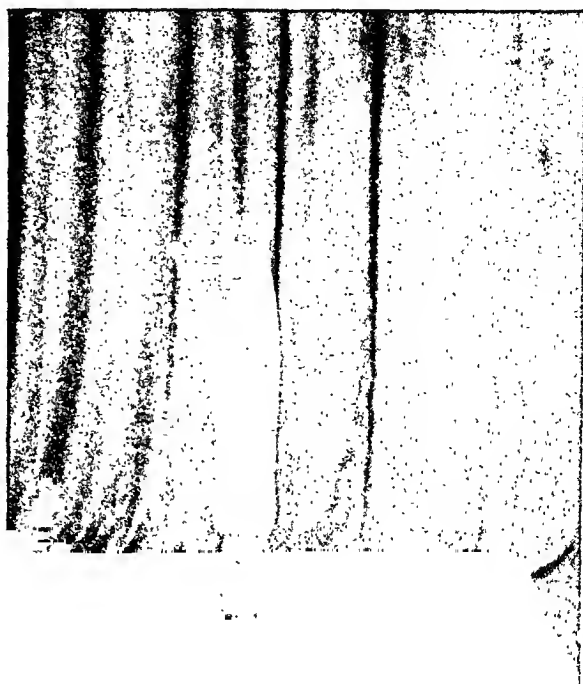


FIG. 5. Syme's prosthesis.

procedures for the final and definitive operations. While it has been the custom to choose from as many as thirty operations and more for the lower extremity according to one's personal experience and whim, the military experience has reduced this number to four basic procedures. These are the Syme's amputation at the ankle (Fig. 1), the below the knee amputation (Fig. 2), the Stokes-Gritti amputation (Fig. 3) and the above the knee amputation. (Fig. 4.) While modifications of these standard procedures are indicated under special conditions, the four basic measures should meet the needs of the average case.

*Syme's Amputation.* This type of amputation should be used for any injury to the foot in which the loss of tissue is proximal to the tarsometatarsal joints. The loss of this joint makes weight-bearing difficult and attempts to save that portion of the foot results in unsatisfactory amputations which are disabling, time consuming and frequently requires reamputation with resulting economic disability. Syme's amputation provides an adequate and desirable end-bearing stump. Direct weight is borne on the skin flap made from the original heel, long accustomed to weight bearing.

In this amputation the tibia and fibula



FIG. 6. Stokes-Gritti prosthesis.

are transected at a point about  $\frac{1}{4}$  inch proximal to the articular surface of the tibia. The os calcis is removed subperiosteally preserving the skin of the heel which is then used to cover the cut ends of the tibia and fibula.

In the Syme's and Stokes-Gritti amputations the resultant stump is end-bearing. The lack of popularity and even opposition to these procedures in the past has been encouraged by some limb makers who found it difficult to construct satisfactory prosthesis for these stumps. This is a weasel attitude particularly when we review the excellent prostheses made in service amputation centers by recently trained personnel. In this regard the Canadians were a large factor in stimulating interest and enthusiasm for these methods in view of their long successful experiences.

*Below the Knee Amputation.* In any amputation above the ankle, the optimum site is 5 to 6 inches below the knee. At this level the optimum conditions of leverage and support are available. Longer stumps can be fitted with boot or "Muley" legs but the stumps soon break down from excessive asymmetrical pressure. Stumps of 2 to 3 inches below the knee can also be

effectively utilized especially if most of the muscles clothing the tibia and fibula are removed, leaving a stump essentially of skin and bones.

In the standard operation below the knee the patient is placed on his face. Slightly unequal flaps are made with the anterior flap somewhat longer. The flaps are reflected and held in place with a single suture to avoid handling and retraction. The muscles are cut through somewhat obliquely in order to secure a graduated conical stump with a large knife. The interspace between the fibula and tibia is also cut through with the same knife. The tibia is incised in a circular manner and the periosteum stripped distally and saved through. The fibula is treated in the same manner but is cut 1 inch shorter using a Gigli saw. The anterior crest of the tibia is bevelled. The nerves are carefully isolated, cut sharply and allowed to fall back into their intermuscular spaces without unnecessary traction, or manipulation, injection or other handling. The large vessels are seized, clamped and tied and the tourniquet removed. The remaining bleeding is controlled by pressure and hot laps or by electrocoagulation if available. The skin flaps are closed with interrupted sutures and drains inserted for forty-eight hours. Drains were found to be necessary because of frequent hemorrhage and hematoma formation.

The resulting stump is satisfactory for the routine pursuits of life. Weight is not borne on the end of the stump but on three pressure bearing areas, the internal condyle of the tibia, the tibial tubercle and the head of the fibula. The fibula was rarely removed except in exceedingly short stumps. If the artificial limb is fitted properly, these pressure areas will carry the weight evenly distributed. When the weight is improperly distributed excessive weight falls upon one of these points causing skin irritation, pressure sores and inability to wear the prosthesis. Accuracy of limb fit avoids this complication. Where excessive weight is required the

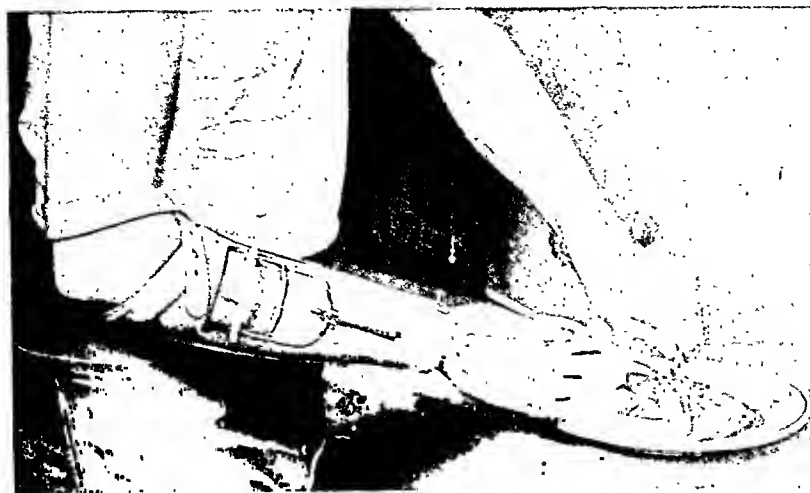


FIG. 7. Cineplastic prosthesis for forearm.

limb maker can so distribute the weight bearing strain to other parts of the thigh and ischium as to relieve the amputee from pain and discomfort.

These weight bearing points must, therefore, be free from scar or defect to permit them to carry out their new physiological demands. In above the knee the weight is transferred to the ischium but depending on the length and shape of the stump some of the weight is carried on the circumference of the thigh stump. In very short below knee stumps the weight is shared between the weight bearing points previously mentioned and the thigh lacer or corset. In exceptional cases some of the weight in these short below knee stumps can even be borne on the ischium through the medium of a blocked roll of leather on the upper end of the thigh lacer.

It is important to remember these four basic types of amputation. Remember that they are the most practical from a functional and prosthetic point of view. Modifications of these procedures may be indicated for pathological reasons but not for prosthetic purposes.

*Upper Extremity.* In the upper extremity many attempts have been made to restore the prehensile function of the hand by means of surgical methods. The cineplastic operation is in this category. By means of skin canals in muscle groups of the forearm or upper arm prosthetic devices can be operated in a natural and automatic fashion. In other instances the

forearm can be split into two finger elements of radius and ulna and their approximations provide prehensile power. For the bilateral blind amputee the retention of tactile sensation is not only desirable but indispensable. However, these methods as well as the utilization of the wrist movement in mid-carpal amputations are special methods to be utilized to meet the needs of specific cases. The basic amputations are the above wrist, below elbow and above elbow amputations. Disarticulations are to be avoided for prosthetic reasons.

#### AFTER-CARE OF STUMP

*Contractures.* The third step in the rehabilitation program of the amputee was concerned with the after-care of the stump. This matter has always been neglected or overlooked in civilian life and bears considerable and thoughtful attention. Many of the difficulties in limb adjustment can be traced to stumps that are contracted, weak or improperly shrunk. The limb manufacturer is frequently criticized for his product when the fault owed its origin to faulty habits begun soon after operation. These contractures of the hip and knee can be prevented by proper posture in bed, by the avoidance of comfortable pillows under the stump and by exercises designed to maintain the full length of the stump and its adjacent joint. When the contracture is severe it is a mistake to fit that patient



FIG. 8. Cineplastic prosthesis for above the elbow.

with a limb until the contracture is corrected by manipulation, gradual traction or other means.

**Shrinking.** Shrinking of the stump has always been regarded as an unnecessary and unpleasant task by the amputee. He knows that the stump will shrink with time and hence cannot understand why he must pay much attention to this chore. But shrinking cannot be left to time or indiscriminate attention. Only by systematic care can the proper shape of the stump be achieved and the shrinking process be expedited so that the permanent limb can be worn. Furthermore symmetrical development of the skin resistance to pressure prepares the amputee for comfortable as compared to uncomfortable limb wearing. Irregular attention to shrinking also invites intermittent changes in volume of the stump which postpones the application of the permanent limb and invites circulatory and neural trouble.

**Exercise.** There is a third phase of stump care that has also been overlooked but one which received considerable attention in military practice. This was concerned with the exercise of the stump. In

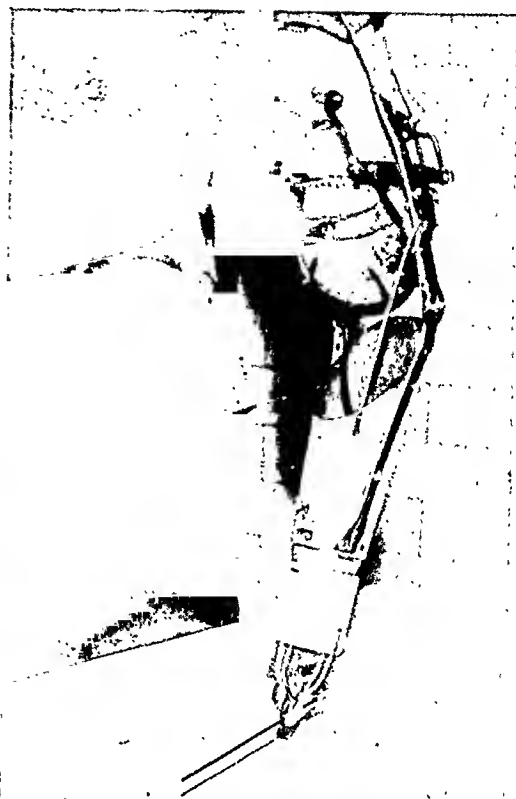


FIG. 9. Cineplastic prosthesis with interchangeable utility hook.

the thigh stump for example it was frequently found that a considerable imbalance resulted favoring excessive activity of the abductors over the adductors. By the exercise of the adductors and the extensors the tendency to an abduction gait was either prevented or corrected. This permitted the amputee to walk in the proper manner with his muscles so balanced as to maintain good mechanical alignment. While this exercise program may be optional for some of the patients it is indispensable for the patient with a bilateral amputation above knee. With poor abdominal muscles he is unable to balance himself and thus becomes discouraged early in his training period. These exercises are undertaken not when the prosthesis is secured but they are initiated soon after the operation. For the individual with severe amputations, the advantage of general muscle training even for the muscles not directly employed in operating the prosthesis is obvious.



## PROSTHESIS

We have discussed the general problems of the amputee, how his amputation produces physical, emotional and social by-products which may overwhelm him in his efforts to make a livelihood. Yet all these problems can easily be solved by means of a properly constructed and fitted prosthesis. The artificial limb restores his functional defect by giving him another source of power to ambulate. The prosthetic device makes him look and feel whole and thus restores confidence in himself as a normal person. Finally, by the restoration of his physical appearance he is restored to social normality.

And what were the contributions of the war to the advancement of prostheses? We were led to expect miracles from the inventors' pipe dreams. After all we had performed a miracle of production. We had invented an atomic bomb, we had developed a thousand and one engineering improvements which gave us the measure of superiority against two of the greatest fighting dynasties in history. Could not this same engineering genius devise new miracles in the form of prosthetic devices? Alas neither private industry nor government mobilized engineering skills have found the Rosetta stone to unlock the mystery of human movement. Some minor improvements are in the course of development; some ideas like the suction socket have been rediscovered by the Germans after an American first described it more than eighty years ago. In the main there have been no major improvements. Plastics are still in the first stage. Cosmetic gloves show promise. The basic material ideas employed in artificial limbs today are those that have been in use for more than fifty years. This is not to be construed that they are not satisfactory for they have given comfort and utility to millions of users.

But there are other contributions of the war to the problem of prosthesis that are just as important as improved materials or

special devices. This has to do with organization of prosthetic services. At the amputation centers the prosthetic service was concerned with three phases, the selection of the prosthesis, its fabrication and the fitting. The selection of a prosthetic device was the proper responsibility of the medical officer who was trained not only as an amputation surgeon but also as a limb fitting surgeon. This is a new departure in this country for only in England at the Ministry of Pensions center at Roehampton does this obtain. This means that as a result of war experience the Army and Navy trained surgeons to be able to inspect a limb and critically evaluate it. Thus he was in a position to certify as to its value in the given case. This is a far cry from the average surgeon who must accept the limb makers judgment unless he has had the special opportunity to familiarize himself with problems of prosthesis.

Selection of prosthesis is of especial importance in the upper extremity. For the lower extremity prosthesis is pretty well standardized. In the upper extremity, however, the prosthesis is selected not just to fit the patient's stump, but to fit his whole personality and total industrial and social needs. There is no one miracle arm that will answer all these demands. An interchangeable dress and work arm will have to meet the needs of the average person in industry. But whether it is to be operated by standard lanyards and shoulder controls or by cineplastic controls will always be the personal decision of the patient himself.

The establishment of facilities for the fabrication of the prosthesis in the hospital amputation center was a distinct innovation. Not only were standard materials such as wood fiber and metal employed but experimental research was carried on with plastics. The advantage of this program of fabrication and fitting for the patient was obvious. Instead of bringing the patient to the limb fitter the latter was brought to him. The fitting of artificial limbs is an art requiring great skill and experience yet the



military limb making and fitting personnel gradually developed these skills after many false starts.

#### TRAINING

The fifth step in the rehabilitation program of the amputee was the training program instituted for the adjustment of the amputee to his limb. This, too, was an innovation not only for the military establishments but for the whole limb industry. It filled a serious gap in the total adjustment of the amputee that had been given too little attention in the past. One of the shortcomings of private limb industry was their inability to furnish proper training in the use of the limb. While a certain number of amputees adjusted themselves quickly to their limb and became satisfactory walkers or users of arm prosthesis, the majority made only a mediocre adjustment to their limb. Another group found it impossible to wear their limbs at all. By systematic training the middle group became excellent walkers while even those with above knee bilaterals and other serious handicaps became satisfactory walkers.

The training program required trained personnel and systematic activities as a result of which the patient learned balance, proper gait, and control and ability to make the most out of his limb. After basic train-

ing was completed training and conditioning were continued to include all the routine pursuits of life, dancing, athletic sports, roller skating, etc. Thus the amputee was prepared to take his place at work in the community and in the family without asking any favors.

#### SUMMARY

This then was the contribution of the war toward the advance of knowledge concerning amputations that only by an integrated plan of action can the amputee be properly served. Such a program includes the five points of psychological preparation, surgery, after-care of stump, prosthesis and training. The war experience points a lesson to those of us who in civilian life are responsible for the rehabilitation of the physically handicapped. In four years that produced 18,000 military amputees 120,000 civilians lost their limbs by accidental injuries and disease. For them no comprehensive program comparable to the military program exists; but if they are to be reassimilated into American life, they must be provided with those facilities. It is the hope of the Office of Vocational Rehabilitation that civilian centers will be established that will follow the satisfactory trend of military amputation centers.



# FREE TENDON GRAFTS IN SECONDARY FLEXOR TENDON REPAIR\*

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A COMMON injury requiring the use of a free graft in secondary repair is the severed deep flexor tendon in the distal palm or proximal phalanx. The tendon is disrupted in the region of the proximal annular ligament where a primary suture frequently fails, unless it is done with the most exacting technic under favorable conditions. Severed tendons complicated by fractures of the metacarpals or phalanges, as seen in crush and missile injuries, are repaired following union of the fractures, resurfacing if necessary and joint mobilization. In clean wounds, even though tendon repair is delayed, severed palmar and digital nerves can be sutured at the time of primary wound closure.

This discussion deals only with those patients that come to secondary repair because of a loss of interphalangeal joint flexion. Our problem is the restoration of a strong, freely gliding tendon of sufficient amplitude to permit the finger to be flexed in coordination with the other fingers through a useful functional range. We resort to a free graft or transfer, because of tendon retraction and the desirability of having an intact tendon within the finger. In general, one badly injured finger is not worth reconstruction. When the hand injury is extensive, however, our aim should be to restore any part which may contribute to the end functional result. For example, a free graft may not fully flex a finger but it may stabilize it to such a degree that a good pinch with the thumb is possible. For the best results in free flexor tendon grafting the palm and fingers must be covered by skin free of scar, the joints must be mobile and good sensation must be present.

If the sublimis tendon is intact, producing good proximal interphalangeal joint flexion, a free graft is not indicated. It is better to fuse or tenodesse the distal interphalangeal joint at approximately 30 degrees of flexion. In primary repair, when

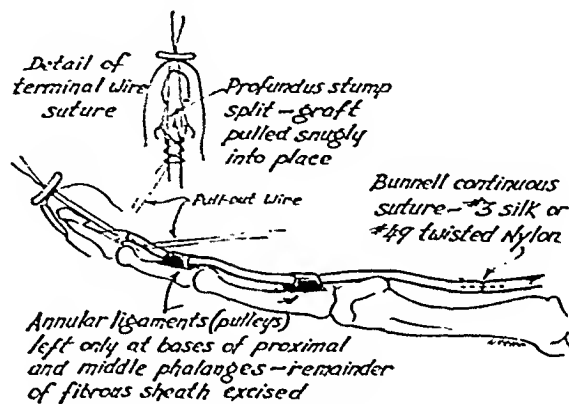


FIG. 1. Sketch showing free tendon graft.

the profundus tendon is severed distal to the sublimis bifurcation in the region of the middle phalanx, an end-to-end approximation of the tendon may be possible. The suture should be made as near the profundus insertion as possible even if it means sacrificing a portion of the distal stump.

## OPERATIVE PRINCIPLES AND TECHNIC

The fingers and palm are opened by lateral and curved incisions under tourniquet hemostasis. (Fig. 3.) If the sublimis tendon is to be used as a free graft, it can be withdrawn through a transverse incision at the wrist. Small caliber tendon grafts are preferable, for they are readily vascularized and are not constricted by the rigid annular ligaments. The palmaris longus or the toe extensors make excellent grafts and are easily obtained. They will hypertrophy if necessary to meet the functional demand placed upon them. Free grafts undergo swelling during the early postoperative

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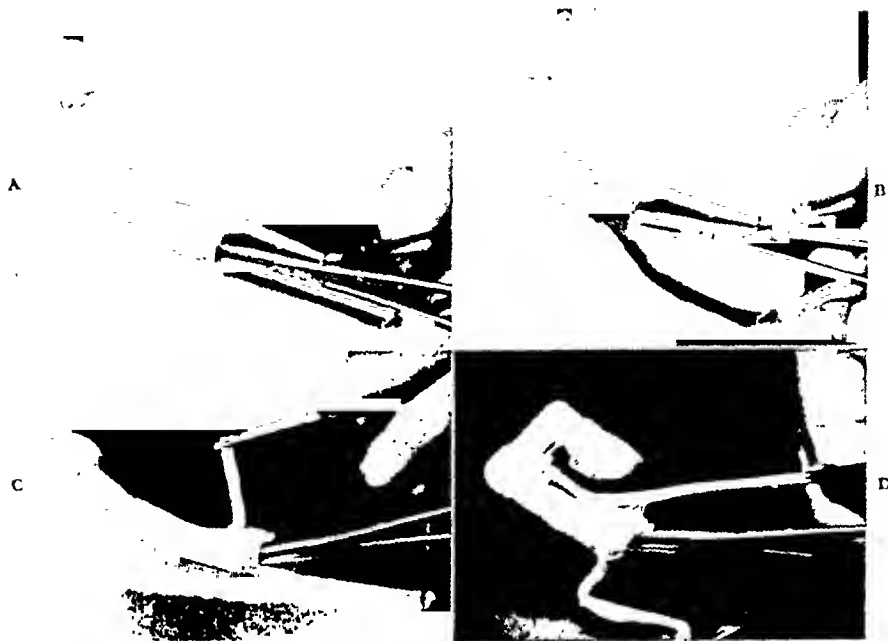


FIG. 2. A and B, an intact finger freshly amputated showing the extent of the fibrous, flexor tendon sheath. Traction on extensor and deep flexor tendon produces only limited extension and flexion. The tendon has remained inactive within the sheath for several months following a wrist injury and the tendon has become adherent. C and D, excision of the sheath excepting two pulleys permits improved extension and full flexion. A similar condition exists when a free graft is placed within a fibrous sheath. By eliminating all but two pulleys, adherence of the graft to a rigid structure is partially eliminated.

phase and pressure necrosis or adhesion of the graft may result if there is not ample space within the annular ligaments. If the graft lies on a cicatricial bed or exposed bone, paratenon from over the triceps tendon should be interposed to form a gliding mechanism or the graft can be transplanted with its paratenon intact.

One of the most important features in preparing the finger for a free tendon graft is a complete excision of the fibrous tendon sheath, excepting enough of the pertinent pulleys (annular ligaments) to prevent bowstringing. (Figs. 1 and 2.) They are located near the bases of the proximal and middle phalanges. If they are destroyed or collapsed, only the proximal one should be reconstructed at the time of tendon grafting. The flexor tendon remnants are removed, leaving only the stump of the profundus tendon at its insertion. (Fig. 1.) Soft tissue and not the tendon sheath is a prime requisite for good function of free tendon grafts within fingers.

When a retracted tendon is prolonged with a free graft, the length of the graft must be carefully determined to insure coordinated muscle balance and function within a useful range. A graft will shrink somewhat but a retracted muscle may compensate by an increase of amplitude. A graft is approximately the correct length when it holds the finger in a neutral position with a flexor tone equal to the normal finger. Correct tendon graft length is facilitated by placing a strong proximal suture first; then, with the graft threaded through the pulleys the distal suture can be placed at the proper tension.

A profundus tendon may retract less than a sublinis tendon when severed, if it remains in continuity with an intact lumbrical muscle or if it is checked by an adjacent profundus tendon. Before any severed tendon is prolonged with a free graft, its amplitude should be determined by traction, for it is futile to prolong a severely contracted flexor muscle with a



FIG. 3. A to H, steps illustrating the use of a free graft to repair a severed profundus tendon. Note the site of injury and the testing position of the intact index, middle and ring fingers. The injured portion of the tendon is discarded and a palmaris longus graft is sutured to the profundus at the lumbrical level, threaded through two pulleys and united to the profundus stump at the terminal phalanx with steel wire. With the graft in place, the finger assumes the same degree of flexion as the intact ring and middle fingers. Between two and three months of persistent exercise beginning three weeks postoperatively are required to gain function.

graft and expect sufficient amplitude to develop for full finger flexion. In fingers, either the profundus or sublimis can be used for power. The profundus are the stronger and are preferable but only that of the index finger has full independent action. The sublimis are all independent. A free graft of either or of all the three common profundus tendons must therefore be carefully coordinated if the middle, ring and

little fingers are to flex and extend in unison. In some few patients it may be desirable to utilize a sublimis for power if its amplitude is greater. The sublimis of the little finger is usually too small for use, either as a graft or for power. Whenever a profundus tendon is prolonged with a graft, additional motor power can be gained by suturing to it the associated sublimis tendon at the wrist.



FIG. 3. 1 and J, range of motion gained during the first six weeks of active exercise. About 15 degrees of flexion have been gained at the distal interphalangeal joint. A complete range should result by the end of six months.



FIG. 4. Method of exercising finger to gain flexion of interphalangeal joints by first holding the metacarpophalangeal joint rigid, thus transmitting the pull to the proximal interphalangeal joint; then by holding both metacarpophalangeal and proximal interphalangeal joints, the pull can be directed toward the distal interphalangeal joint.

A sturdy, proximal end-to-end suture and firm fixation of the tendon graft at the insertion is imperative. The Bunnell continuous suture with untreated silk (No. 3) or twisted Nylon (No. 49) is preferred for the proximal tendon juncture and his stainless steel wire (No. 34) technic at the insertion. (Figs. 1 and 3.) If the profundus is used the graft should be sutured at the level of the lumbrical origin in the soft tissue of the palm—the tendon juncture may be covered by this muscle. Full finger flexion cannot be gained, if in the presence of an intact lumbrical, the graft is made too long or if the lumbrical is contracted. The lumbrical muscle acts both as a flexor of the metacarpophalangeal

joint and as an extensor of the interphalangeal joints; its base (origin) is the shifting profundus tendon. Actually, the profundus muscle has a dual insertion through the tendon and the lumbrical. Its direct pull is transmitted to the terminal phalanx but at

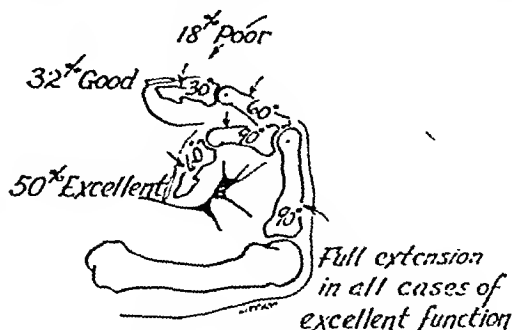


FIG. 5. Criterion for results as expressed in this paper.

all times excursion of the tendon is acted on by the lumbrical; as the finger is extended the lumbrical relaxes the interphalangeal joints by advancing the profundus tendon. In finger flexion the lumbrical through its extensor action on the interphalangeal joints prevents acute flexion of the distal interphalangeal joint. Kaplan<sup>8</sup> has aptly termed the lumbrical as the moderator between the long extensor and flexor tendons.

Fowler has shown that an intact ring finger sublimis tendon can be detached at the proximal interphalangeal joint, withdrawn through a palmar incision and transferred to the little finger to replace a severed profundus tendon. The ring sublimis tendon can also be transferred to the terminal phalanx of the thumb, if a damaged flexor pollicis longus tendon is not amenable to repair either by suture or graft or especially if the muscle has been damaged. This transfer eliminates the use of a free graft and provides an intact tendon from muscle to insertion, which is free of any suture. However, the transferred tendon acts as a free graft, in that it must also regain a blood supply for its survival. Tendon grafts do poorly in anesthetic fingers and should not be placed until sensation has been restored through nerve suture.



FIG. 6. Case 1. A to C, laceration of sublimus and profundus tendons of all fingers at distal palmar crease. Primary suture with black silk resulting in a useless hand. Results following one-stage removal of all sublimi and prolongation of the four profundus with free sublimis grafts.

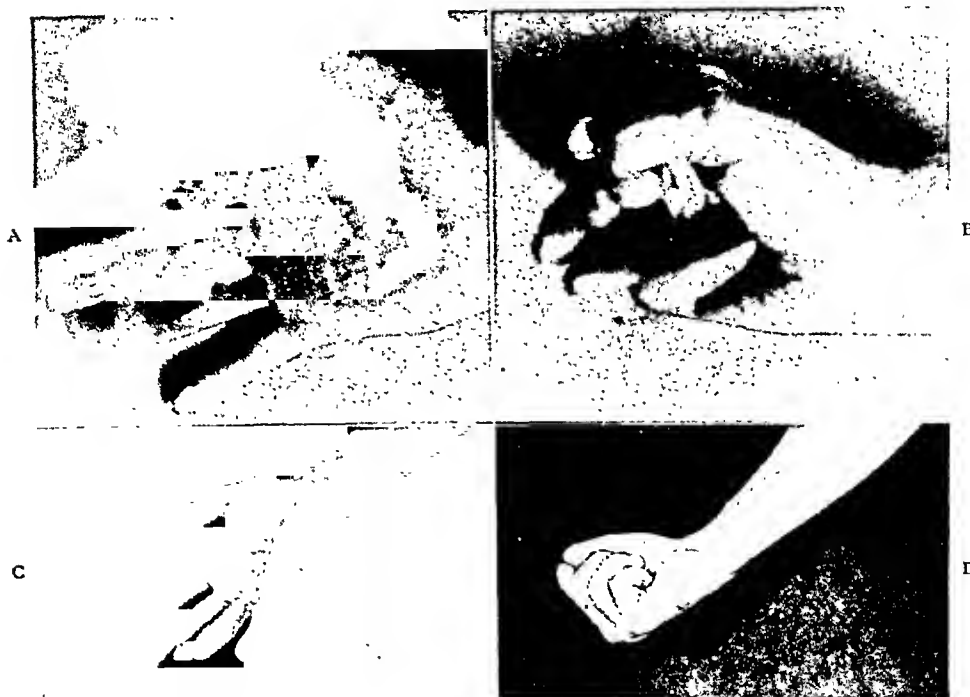


FIG. 7. Case 2. A to D, crushing injury of hand with partial loss of digits and complete loss of middle and ring finger interphalangeal joint flexion. Ring finger resurfaced with pedicle flap. Free tendon grafts placed in middle and ring fingers. Pulley constructed at middle phalanx of ring finger.

Careful hemostasis and a pressure dressing will prevent the formation of a hematoma in the palm. Stainless steel wire (No. 36) is used for skin closure. Relaxation of the tendon is gained by immobilizing the hand in a dorsal plaster splint with the wrist, metacarpophalangeal and proximal interphalangeal joints each flexed at approximately 45 degrees. The dressing is not disturbed for three weeks and uninterrupted elevation of the hand is important for at least forty-eight hours following operation.

Good primary healing with a minimum of cicatrix is gained through immobiliza-

tion. Early motion has no place in free tendon grafting, for not until three weeks have passed are the tendon junctures united. An untraumatized tendon will not adhere firmly to surrounding soft tissue if left undisturbed for this period. During the early postoperative phase, when the graft is swollen, softened and avascular, motion promotes the formation of scar and adhesions. The cicatricial index and reaction to injury varies in patients and has some influence on the final functional result in tendon surgery.

At the end of three weeks the skin sutures are removed and the pull-out wire

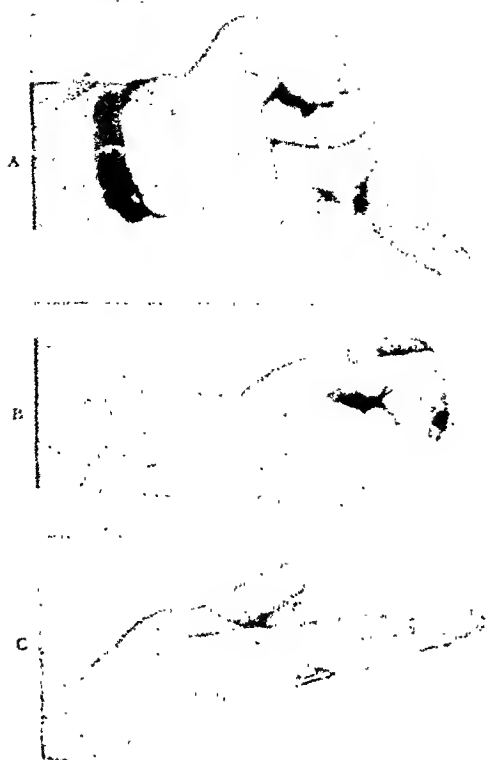


FIG. 8. Case III, F. F. A to C, flexor tendon laceration. Function gained two months after free tendon graft.

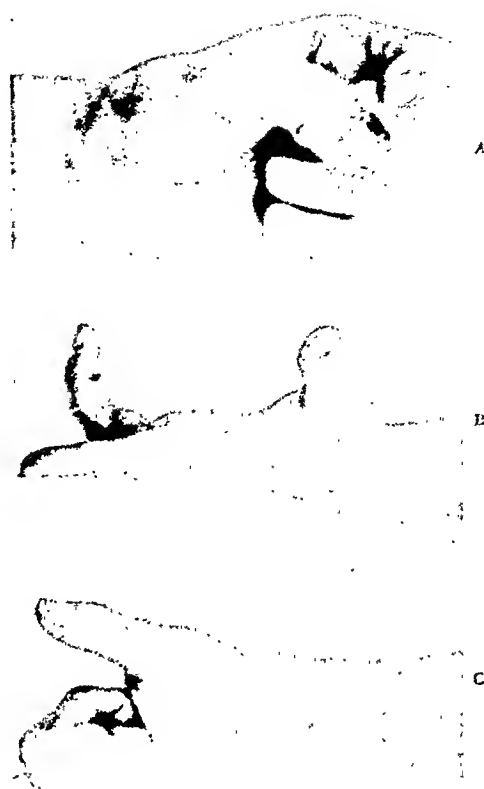


FIG. 10. Case 5, J. B. A, B and C, flexor tendons lacerated at base of index finger. Primary silk repair resulted in a flexion contracture at the proximal interphalangeal joint. Complete interphalangeal joint flexion and extension regained in three months following a free graft.

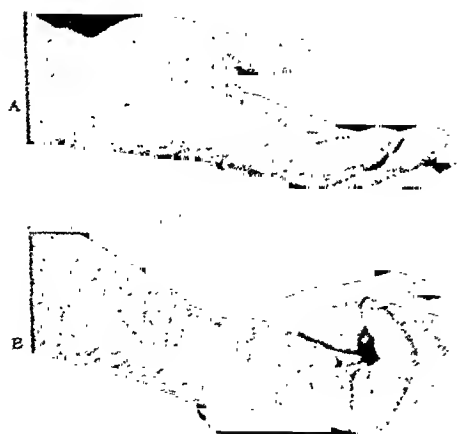


FIG. 9. Case 4, N. G. A and B, crushing and lacerating wound involving ulnar aspect of palm, severing ring and little finger flexors and ulnar nerve. Nerve repair and free tendon grafts done together. Poor result on anesthetic little finger and good result on partially anesthetic ring finger. Sensation should have been restored to the fingers prior to tendon grafting.

at the terminal phalanx is withdrawn. Passive joint exercises are carried out during the following three or four days and then active flexion is started. During the latter part of the fourth week the patient is instructed to hold firmly in extension the metacarpophalangeal joint, thus transmitting the pull to the proximal interphalangeal joint. (Fig. 4.) If this is not done flexion will be gained only at the former joint. A gripping block made of soft wood  $3\frac{1}{2}$  by  $1\frac{3}{4}$  by  $\frac{5}{8}$  inches is excellent for exercising the finger. Persistent active exercise is important in gaining good finger flexion.

#### RESULTS

In many patients a near complete restoration of flexor function has been

achieved, in few has a complete failure resulted. An analysis of the failures and poor results shows that generally one or more contraindications to favorable results were involved. However, in one patient the graft was ruptured from its insertion: in another patient, following tendolysis in the palm, the tendon ruptured ten days postoperatively while being exercised. Pressure necrosis disrupted one tendon graft at the proximal pulley.

A total of thirty-six free flexor tendon grafts were placed in the fingers of twenty-eight patients. The principles as outlined by Bunnell were followed in all patients. Fifty per cent of the results were excellent, 32 per cent were good and 18 per cent poor. (Fig. 5.)

In badly crippled hands, a limited range of finger flexion and extension gained through tendon grafting, may be so useful that to classify the result as poor on range alone is unjust. In the otherwise normal hand, however, a finger that does not flex within the good category is a detriment to general hand function.

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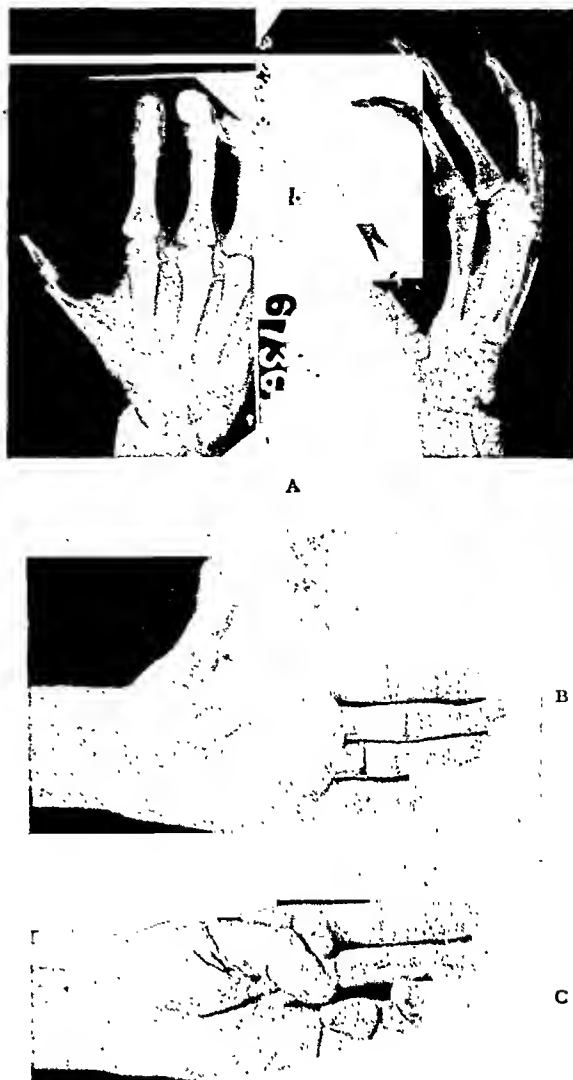


FIG. 11. Case 6. H. S. A, B and C, compound fracture dislocation of thumb metacarpophalangeal joint with loss of metacarpal head and long flexor tendon. Joint fusion was followed by a free tendon graft from wrist to terminal phalanx; full flexion and extension regained.

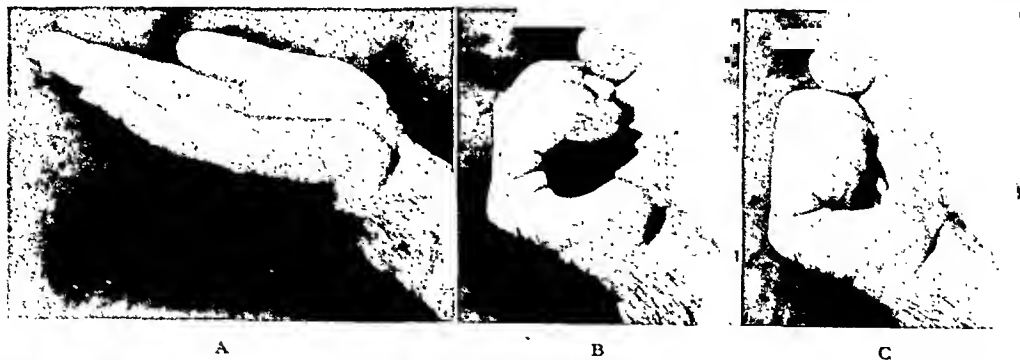


FIG. 12. Case 7. A, B and C, function gained through free flexor tendon graft of the little finger.



# PLASTIC SURGERY IN ACUTE TRAUMA\*

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THE surgeon of today whose work includes the surgery of acute trauma must be prepared to use every method that will facilitate the early recovery of the patient, prevent deformities and disfigurement and by so doing restore the patient to his gainful occupation as soon as possible. To this end he must have thorough knowledge of the practical application of the principles of plastic surgery. At the time of the first actual treatment of the wound, regardless of the extent of the trauma, the surgeon should and must visualize the possible end result, both as to deformity and to loss of function. To minimize either a potential deformity or loss of function he must be alert to the use of any and all of the various procedures of plastic surgery which will probably cover raw surfaces that are present. By covering the denuded area one materially cuts down the cicatrix and permits in most cases early active use of the part, with maintenance of function within mean physiologic limits.

At first, such treatment seems far fetched, especially in many cases of severe trauma with exposure of large vessels and nerves that cannot be covered by preference with remaining skin and subcutaneous tissues. However, in these patients the use of a thin or thick split-skin graft immediately results, many times, in a living graft with excellent covering of the previously exposed areas and obviates the necessity for further or later reconstructive surgery. Frequently, this type of coverage is found to be entirely adequate; however, if later for cosmetic reasons it is found advisable, further plastic procedures can still be carried out on clean, closed tissues.

The early use of grafts not only prevents

fibrosis with its resulting edema but preserves to a great extent a considerable portion of the lymphatic system, permitting possible regeneration of the lymph vascular channels with their early return of function. These grafts also act as a limiting membrane, preventing fluid loss, the entry of bacteria in the wound and permit early application of pressure to the involved area. In short, skin is the normal and superior cover of the internal tissues. The early and proper use of plastic procedures in surgery of acute trauma involving large defects of skin and soft parts can shorten materially the hospital stay of the patient, to say nothing of preserving the remaining function of the involved part. If not so treated, the function might be markedly decreased by the resultant fibrosis, ankylosis and atrophy which develops if the wound is allowed to heal by the process of granulation and cicatrization.

The principles of plastic surgery gained from the Hindus who first practiced rhinoplasty to the Italian masters of the Renaissance, particularly Gaspard Tagliacozzi; Carpus of England; Graff in Germany in the early nineteenth century and then Reverdin, 1871, in Geneva; Ollier in 1872 in Lyons; Thiersch in 1874 and Wolfe in 1875 in Glasgow have formed the basis of our present day methods. These, of course, have been modified and clarified for present day usage by our own confreres following the teachings of the late Dr. Staige Davis of Baltimore; Dr. Vilray Blair of St. Louis and Gilles, Pickerill and Hunt of England. The past war has permitted the development of a group of young, enthusiastic surgeons who specialize in plastic surgery and who have to a marked degree stabilized our modern methods.

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The ideal and primary principle of all surgery is absolute asepsis. Such wounds or recipient surfaces must be surgically clean. Prior to the use of sulfonamides and antibiotics there was always a question as to whether one had attained such conditions but with the advent of these drugs and the local use of the Carrel-Dakin technic or zinc peroxide (and in the future by other antibiotics, bacteriostatics and bacteriolytics now in development) one may carry on with greater assurance of success.

#### TYPES OF GRAFTS

The Celsus type, or shifting of the skin and subcutaneous tissue, is often used to cover exposed bone, such as compound fractures of the tibia. The essential factors are maintained of blood supply, proper venous and lymph drainage and sufficient relaxation of the shifted flap to insure circulation. The tension must be minimal and cannot be expressed in figures. The experience of the surgeon and his surgical judgment must be his guide. This type of graft also provides adequate covering for wounds having exposed bones and tendons, as in the forearm, and will prepare an area allowing further surgical procedures such as bone grafting. After shifting a graft the denuded area over muscle, deep fascia and other soft structure should immediately be covered with a thin or thick-split graft.

*Free Grafts.* (1) Thiersch grafts (epidermal or Ollier-Thiersch grafts). This split graft is generally used to cover the granulating wound surfaces when in the early treatment, by force of circumstance, the wound had to be treated conservatively. This type of graft may also be used to replace mucous membrane since by a certain degree of metaplasia it readily adapts itself to moist surfaces although it never takes on the full characteristics of mucosa. This has been demonstrated by plastic surgeons and in our experience in the employment of grafts used for reconstruction of the nose, the lips and the interior of the buccal cavity. We also have

two cases on record in which there was a complete loss of the urethra 1 inch in length, following a compound fracture of the pelvis that functioned nicely by the implantation of such a graft. (The thick-split graft is used more often to cover large defects). This type of graft has good resistance to infection with a minimal amount of contracture.

(2) Full-thickness, Wolfe or Wolfe-Krause grafts. These grafts are used in reconstructive surgery and have limitations but when employed successfully they give the best cosmetic and functional results. Plastic surgeons are developing its use daily. Brown of St. Louis has had excellent results in its application to facial defects.

*Pinch Grafts or Reverdin.* These grafts are of two varieties, the thin type as first advocated by Reverdin and the thick type known to the modern surgeon as the Davis type. This type of graft is a most useful one and may be used when the circulation is impaired. It is widely used in: (1) directly over the tibia—new or old; (2) severe brush burns of the palms or (3) over an area which must take repeated trauma, as over the end of amputated fingers, toes and metatarsals following a traumatic guillotine amputation of the anterior portion of the foot, or over the heel where cicatrization of surrounding tissues will not permit a full-thickness pedicle graft.

*Pedicle Grafts.* These grafts may be either free open flaps or the tube types (Italian or Gillws). This type is used when there is need to fill defects of not only cutaneous tissues but subcutaneous tissues and deeper structures. According to the availability of tissue these types of grafts are used either open or closed. The tube graft because of its assured blood supply is very viable and can be twisted and turned quite freely. This permits multiple stage transfers or jump technic.

In this paper we cannot discuss the many and varied procedures for the reconstruction of fingers, thumbs, synoplastic stumps, etc., but must limit our discussion

to the early and intermediate stage of the care of wounds. One must keep in mind, however, that the preservation of the length of stumps which might by the use of tube and pedicle grafts be made to carry a prosthesis at a later date, rather than an immediate closure of a wound with a short and useless stump, is the preferable procedure. Here, we mention the use of the so-called reverse thigh pedicle graft and the delayed reverse thigh flap for such reconstructive procedures.

In this discussion we shall limit the field to that of the immediate covering of skin defects caused by trauma, namely, the phases of débridement and reparative surgery and shall omit that phase of plastic surgery that deals with reconstruction, such as bone grafting and the procedures necessary for free nerve and tendon transplants. We believe the third phase can be largely eliminated or minimized by proper early attention to phases one and two.

#### VARIOUS PROCEDURES USED IN ACUTE TRAUMA

*Soft Tissue Wounds Involving Skin and Little if Any of the Subcutaneous Fat.* When there is loss of skin and a portion of the subcutaneous tissue, delayed grafting is indicated with the early treatment of the wound if the tissue does not appear receptive. The treatment here consists of a rational débridement and packing of the wound with thin meshed gauze, either moistened with Dakin's solution or dry, as well as a pressure dressing. After waiting for a period of four to ten days until granulation tissue has developed the skin grafting is carried out. Here, depending on the location of the lesion, either thin or thick-split Thiersch grafts or thick or thin pinch grafts may be used. When there is loss of skin with little or no loss of subcutaneous fat, after proper débridement, immediate grafting using one of the above mentioned procedures may be done.

*Superficial Tissue Wounds with Exposure of Nerves, Tendons, Blood Vessels or Bones.*

When this type of injury is encountered it is proper that following a complete débridement of the wound, an attempt at immediate closure using the Celsus type of skin shift be carried out whenever possible. When by the nature of the wound there is danger of infection or in those patients in whom the wound edges may be sutured for secondary closure following débridement this technic is feasible. Here the interrupted sutures are left long and untied, with dry or moist gauze packs placed into the wound. These are left in place for three, five or seven days until it is believed that by wound inspection and wound bacterial count by direct smear (2 to 4 organisms per low powered microscopic field) infection is not likely, then immediately upon the removal of the packing the sutures are secured and the wound edges approximated. When there is marked loss of substance and complete closure cannot be obtained, the same procedure can be carried out, approximating the skin edges as nearly as possible and filling the defect with either split or pinch grafts. A good rule here is immediate free graft in clean cases and delayed free graft in suspected or so-called dirty ones.

*Soft Tissue Injuries with Bone Involvement.* In these cases the bone factor is the primary consideration. Following the débridement of the wound the bone must be taken care of with reduction and internal fixation whenever possible. Following this, the early closure of wounds over the exposed bone in compound fractures is today the method of choice of the trained surgeon. When this procedure is carried out it not only converts a compound into a simple fracture but prevents infection and permits early bone union. The more recent the wound the more adaptable the tissues. This can be accomplished by the so-called Celsus graft or shifting of skin and subcutaneous tissues. As a rule, the shifted skin flap should be about 2 inches in width, which allows for sufficient blood supply and closure of a denuded gap of about 4 inches of its great-

est width without tension at the suture line. This, of course, is a matter of surgical judgment. The denuded donor gaps left lateral to the shifted skin and subcutaneous tissue leave a fascial plane that should immediately be covered by free split grafts.

The suture material we prefer is black silk (No. 0 or 1) or nylon (Ethicon, No. 0) to be used according to its needs. Sizes vary when a certain tension is necessary or desired.

*Crush Injuries with Traumatic Amputation of Digits.* In these cases it is imperative that the surgeon save as much tissue as possible, especially the palmar and plantar surfaces of the fingers and toes. Here, the use of the Z plastic will allow covering with normal skin of those areas that require tactile sensation, pressure sense and permit the use of split grafts to cover the defects on the lateral surfaces. This is particularly true when the palmar surfaces of the thumb and index finger are involved. This procedure is also applicable to traumatic amputation of the foot and hand, when again the plantar surfaces of the foot or the palmar tissue of the hand should be saved if possible, in order to use these in covering over bone ends. However, in other cases when cosmetics are of prime importance grafts should be applied on the stumps.

*Crush Injuries with Partial or Complete Evulsion of Skin with Possible Later Resulting Amputation.* In these cases it is essential to utilize all vital tissue remaining when an attempt had been made to save the crushed portions of the toe, finger or extremity at the time when first seen. Often in those patients with complete or partial evulsion of the skin when one cannot determine or be sure of the vascular supply, a complete excision of the remaining skin should be done at the base of attachment. Following this complete removal of the underlying fat with replacement of the skin over the vital areas (palm and plantar surfaces), a Wolfe graft with pressure dressings and rest for a period of ten to fourteen days is the

method of choice. (Farmer of Toronto has written more extensively on this subject.) This is a meticulous and time-consuming procedure and is useless unless done thoroughly. Here, keenness of surgical judgment will utilize all viable flaps to the utmost. This is a very useful procedure and if plantar or palmar flaps do not cover the defect, thick split, (Wolfe) or pinch (Reverdin) grafts are applied. Another procedure which can be used in this type of case, except in leg and arm amputations, is the shifting type of pedicle graft.

*Severe Injuries with Much Loss of Soft Tissue, Including Tendons, Muscle or Bone.* Here it is necessary to save all the bone possible, as well as the soft tissue, by a thorough but rational débridement. Following this the denuded area should be covered immediately with skin whenever possible. If a pedicle flap can be swung into the open wound area this should be done immediately so that in five, seven or nine days when the pack is removed from the wound, the pedicle graft can be immediately sutured into position. After healing and take of the graft one has sound tissue to work through when the delayed plastic procedures are carried out on bone and other tissues. At times the area may be temporarily covered with split-thickness graft, converting the open into a closed wound during the periods of waiting for the pedicle graft to develop its blood supply. By use of this early type of pedicle graft one eliminates or limits the formation of scar tissue over the structures upon which later plastic procedures must be done.

It is generally conceded that exposed tendons and cortical bone do not support or nourish split-thickness pinch or other skin grafts; however, we have found in many instances that this assertion does not hold true. Hence, in a fresh wound where these structures are exposed and cannot be covered by the shifting of skin flaps, we have used split grafts directly on tendons, bones, blood vessels and nerves with complete preservation of vitality. The bone

should be irritated to cause minute hemorrhages or revivification which permits the application of thin Reverdin or Thiersch grafts that will obtain adequate nourishment. Here the question of whether to treat these wounds until granulation tissue appears and then grafting, or whether immediate grafting is preferable, has in our minds, been definitely resolved in favor of the latter for by so doing some partially devitalized tissue may be saved. The graft acts as a protecting membrane and permits the deposit of needed nourishing elements, whatever their chemical composition may be.

*Soft Tissue Wounds Predisposed to Contracture Deformities Such as Axillary, Groin, Popliteal Fossa and Antecubital Fossa.* In these cases the extremities should be immediately placed and immobilized in extension by adequate methods (plaster splints, etc.) with the area covered by thick split grafts in order to prevent contracture of the area. Here the graft should be ample to allow for contraction, so that if later plastic procedure are necessary enough transplanted tissues are available. It is easier to remove an excessive portion of the skin than to replace skin in a contracted area.

#### PREPARATION OF RECIPIENT AREAS FOR DELAYED GRAFTING

Various methods can be utilized, depending on the condition of the recipient area. In moderately infected wounds dakinization is sufficient for several days. If dirty, infected or superficial slough is present, (aluminum potassium nitrate) poultice to remove the débris followed by dakinization is an excellent preparation. In patients with micro-aerobic infection zinc peroxide paste, as advocated and described by Meleney, has given us excellent results. This has been extremely useful in those wounds that have partially healed by scar tissue with large deep sulci or trench-like depressions extending many times to the periosteum or the cicatrized interior medullary cavity of bones. Its proper use in

certain cases that cannot be rendered clean by the usual routine procedure aluminum potassium nitrate (or the Carrel-Dakin technic) will give in three to seven days a clean healthy, firm, granulating surface that can readily be grafted. In addition to this, one has at the present time the systemic use of chemotherapy in the form of sulfa drugs, penicillin and streptomycin. We have not found the local use of these drugs necessary, although we do believe in their systemic use.

#### TREATMENT OF RECIPIENT AREA AT TIME OF DELAYED GRAFTING

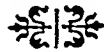
It is imperative that one get good solid granulation tissue. This can usually be obtained by curetting or shaving off the soft superficial layer when redundant or old, exuberant or flabby, insuring a good blood supply for the grafts. One may also use penicillin in solution (40 to 100,000 units in 5 to 10 cc. normal salt solution) injected into and just beneath the granulation tissue underlying the grafts after the grafts have been placed in position. This may also be used in fresh wounds. The tissue surrounding the grafted site may also be injected with this solution. Heilman, et al., have reported excellent results with this method of treatment and we have used it with good results. It is worthy of trial and observation in those cases that are questionable as to sterility of the granulating or recipient surface and it is good in primary and delayed grafting.

Early treatment of any type wound which may involve subcutaneous tissues, fascia, muscles, blood vessels, nerves, tendons or bones and in which there is a loss of protective skin covering, requires the usual thorough débridement with the minimal amount of surgical trauma and the establishment of complete hemostasis. This is carried out by the use of the Carrel-Dakin technic and the so-called non-touch Lane technic in compound fractures. Surgical judgment will tell one how much of the skin wound can be closed by suture; it will also tell one if the residual denuded

area consists of viable tissue, fascia, vessels, nerve, tendon, bone, etc., and if the contamination of these tissues has been kept at a minimum. If these objectives have been obtained, the areas should immediately be covered by grafts of proper choice and maintained in position by a firm compression bandage of a type most effective with the operation. At no time should strong tissue-devitalizing antiseptics be

employed in or about the wound or the donor area. The donor area can readily be dressed by covering it with simple flamed adhesive plaster, plus a pressure dressing.

The foregoing are elective methods used on our service—these have been screened from reading the literature of our predecessors, personal observation and frequent contacts with our confreres over the past thirty years.



OPERATION for harelip is usually indicated in early infancy. The deformity is always distressing to the parents and should be repaired as early as possible. Early repair of a cleft lip will minimize lip and nose deformity and aid in molding a coexisting deformity due to a cleft of the alveolar process.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Co.).

# PLASTIC SURGERY IN INDUSTRY\*

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**D**URING 1945, there were 2,000,000 accidental injuries and 16,000 deaths in American industries. Accident costs alone were \$600,000,000 and the total cost to industry was three times that amount.<sup>12</sup> It is small comfort that there were more workers injured in accidents outside industry. Obviously, accidental injuries sustained in industry, therefore, are a problem of great magnitude. The work done by the industrial surgeons in caring for the injuries and directing the rehabilitation of the injured workmen is a matter of pride for the entire medical profession.

Our purpose in writing this paper is to stress the importance of the principles of plastic surgery as an aid to the industrial surgeon in this work.

## GENERAL CONSIDERATIONS

Three important factors must be considered by the surgeon confronted with a traumatic wound; time of injury, the nature of contamination and the extent of the wound.

*Time of Injury.* Probably the most important factor is the duration of the injury at the time repair is to be performed. To be sure, this is more vital in wounds involving tendons than in wounds of the face but it must be considered at all times. It is generally agreed that wounds of the face can safely be repaired at any time within eighteen to twenty hours after injury and that soft tissue injuries elsewhere on the body should be repaired within eight to twelve hours. We have arbitrarily limited primary repair of tendons to those patients seen within four hours, as recommended by Mason.<sup>10</sup> Repair of flexor tendons, particularly of the

fingers, should not be attempted after two hours because of their location in a firm fibrous canal. Infection following repair in this area is particularly disastrous, both from the standpoint of resultant limitation of function and the difficulties encountered in obtaining satisfactory results through secondary repair following such infections.

The possibility that the local and systemic use of the newer chemotherapeutic agents may alter this factor is to be considered but we are inclined to adopt such a trend with caution.

*Nature of Contamination.* The nature of wound contaminants is of great importance in making a decision to perform a primary repair, particularly in compound fractures and wounds involving tendons and nerves. Alpha and beta hemolytic streptococci and coagulase—positive *Staphylococcus aureus*, the organisms which are responsible for the bulk of severe infections, are rarely introduced into a wound at the time of injury. These usually are from a human source and are introduced later from examining fingers, mouth spray, dust from the ward or dressing rooms or from unsterile first aid dressings, such as soiled handkerchief. This is, of course, exclusive of tetanus and gas-forming organisms.

*Extent of Injury.* Occasionally, the patient has sustained multiple injuries and his general condition does not permit primary repair of those injuries which are the concern of the industrial surgeon or the plastic surgeon. This factor also includes the local extent of a wound—can it be repaired in the office or plant operating room or should it be done in a hospital?

Secondary repair of wounds is necessary because of poor cosmetic or functional results or because primary repair at the

\* From The Straith Clinic for Plastic and Oral Surgery, Detroit, Mich.



time of injury was not advisable. The plastic surgeon must consider the manner in which the wound healed, the degree of impairment of function and the condition of surrounding soft tissues before electing to perform a secondary operation. Wounds healing by primary intention may be revised in three to six weeks. When infection has occurred an interval of four to eighteen months should be allowed. A complete loss of function should be corrected as soon as possible. Finally, it may be necessary to remove scars and provide normal skin by swinging flaps or to perform a skin graft before secondary repair of deeper structures can be attempted.

**Anesthesia.** Local anesthesia should be employed whenever possible. This may be affected by infiltration or by nerve block. Five-tenths to 1 per cent novocaine containing five to six drops of adrenalin chloride to each ounce is a safe local anesthetic. Smaller quantities of a 2 per cent solution may be used for nerve block but the 1 per cent solution is usually sufficient. A 4 per cent solution of cocaine used topically is a useful adjunct in surgery of the eyelids, nose and mouth.

#### SOFT TISSUE INJURIES

Soft tissue injuries cause the greatest concern when they involve an area of the face. The principles governing the surgical repair of such wounds in our clinic may well be adapted to soft tissue injuries of any part of the body. The so-called "plastic closure" of operative wounds has been used by some general surgeons with excellent results.

After a thorough examination has shown the injury to be limited to the soft tissue, cleansing is affected by a thorough scrubbing with green soap and water. Care is used to cleanse the surrounding skin first; then after anesthesia is obtained the depths of the wounds are cleansed. The wound and the adjacent areas are thoroughly irrigated with sterile water. The skin surfaces are sponged with alcohol and the area suitably isolated with sterile drapes.

Our method of closing lacerations is by no means original or unique. When the wound is jagged, so that a fine closure cannot be obtained, the skin edges are trimmed and straightened. Excess subcutaneous tissue is excised and the skin

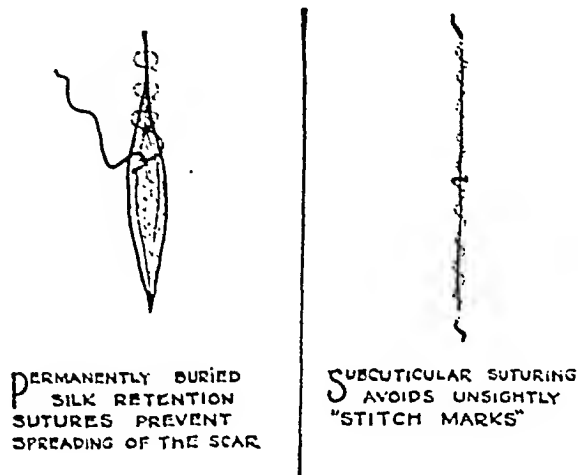


FIG. 1. White silk, inverted, vertical mattress sutures close the subcutaneous tissues, with the knot deep in the wound. Subcuticular sutures oppose the skin edges accurately, eliminating suture marks.

is undermined for a sufficient distance in all directions so that the skin edges may be coapted without the slightest tension. Absolute hemostasis is accomplished by pressure and through the use of white silk ligatures. Black silk is never buried since it sometimes results in visible dark markings under the skin.

The subcutaneous tissue is then closed by means of an inverted vertical mattress suture of white silk with the knot in the deepest extent of the wound. If these sutures have been correctly placed the skin edges should be in apposition. A subcuticular suture (Halstead) of No. 0000 or No. 000000 nylon (or occasionally fine stainless steel wire) is used to assure perfect alignment of the skin with slight eversion and usually a few interrupted horsehair sutures are inserted and tied with one double twist knot. (Fig. 1.) Occasionally, in small wounds two continuous sutures of horsehair or nylon are used, the first serving to close the subcutaneous tissue and the second to close the skin. It is advisable to bring the subcuticular suture

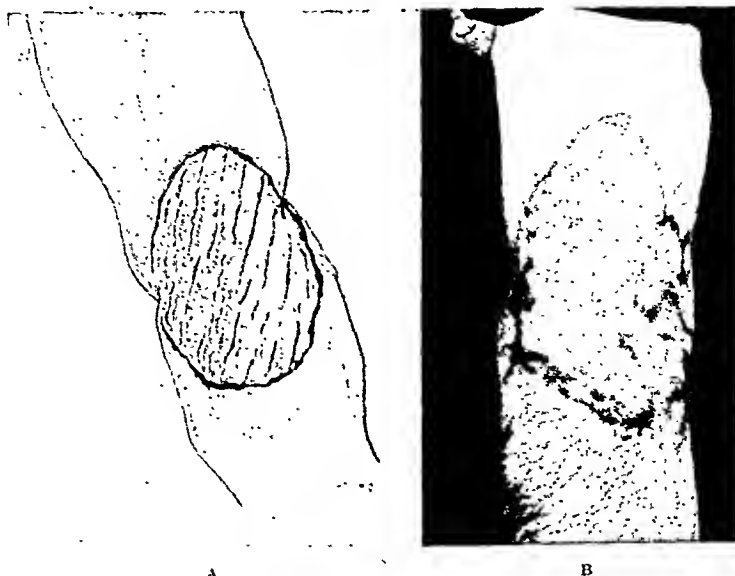


FIG. 2. A, artist's drawing of injury incurred when arm was caught in some gears. The shredded skin was attached only by a small pedicle at the medial margin. On the operating table, the skin became cyanotic and was immediately excised. A split-thickness graft was applied; B, healed skin graft. The period of disability was greatly decreased and the functional result was excellent.

to the surface about every  $1\frac{1}{2}$  inches in longer wounds. The external loops can be cut and the sutures removed in sections with greater ease.

Such a method of suture completely eliminates the possibility of unsightly suture marks. The horsehair sutures are removed on the second or third day and the nylon subcuticular suture is removed on the tenth day, although it may be left undisturbed for a longer time.

The closure of wounds in which there is loss of substance may tax the ingenuity of the surgeon. Skin grafts may be necessary to preserve the function of exposed tendons but such a procedure is used on the face only as a last resort after all other methods of closure have failed. They are, however, sometimes used to facilitate healing and are later excised. When a wound is so badly torn that the skin is not viable it may be completely excised and a skin graft applied. In such an instance (Fig. 2) a patient's arm was caught in some gears. The shredded skin was partially sutured but became cyanotic before the repair was completed. The injured skin was removed immediately and a split-thickness graft was applied. A complete take resulted.

Wounds involving both skin and mucous membranes, such as those seen in the lips and cheeks, are immediately approximated by a figure of eight suture of No. 0000 nylon with the knot tied in the mouth. This type of suture eliminates the need for any tension in the skin sutures. By the tenth day all sutures have been removed leaving none in the depths of the wound. The mucous membrane is so loosely closed by this method that drainage is adequate should infection develop.

Lacerations of the tongue heal well and simple care in the suturing is the only requirement. Anesthesia can be accomplished easily by nerve block.

Injuries to the eyelids present special problems because of the marked deformities resulting from very slight contractures. It is essential that the palpebral margin be in perfect alignment. The first suture is placed in order to accomplish this. The points of entrance and exit are selected approximately 3 to 4 mm. on either side of the laceration just posterior to the cilia near the grey line.

This suture when tied also supplies an excellent means of traction during the rest of the repair. The conjunctiva is closed

with interrupted black silk sutures. The skin, muscle and tarsal plates are approximated with interrupted horsehair sutures.<sup>17</sup> Kazanjian<sup>7</sup> and Spaeth<sup>18</sup> advocate suturing a vertical laceration of the lower lid in a series of Z-plastics so that the skin sutures are offset from the muscle and conjunctival sutures. They believe that subsequent contracture is thereby minimized.

The nasal skin, because of the enlarged pores and excess secretions over the tip of the nose, presents a serious problem when lacerations occur in this area. Healing is frequently complicated by infection and resultant scars are unsightly. Closure can best be accomplished by the use of a subcuticular suture and interrupted horsehair sutures. When the cartilages of the nasal tip are involved the mucous membrane requires suturing only when the structure of the nose has been markedly distorted. Frequently, nasal packs of vaseline gauze will suffice to maintain the mucous membrane and cartilage in position until healing is well under way. These can be removed on the fourth or fifth day.

Lacerations of the external ear are mentioned primarily to voice a word of caution. The healing powers of the pinna are remarkable and it is rarely necessary to débride any part of its tissue. It is far better to attempt a repair, no matter how hopeless it may appear and remove necrotic tissue later if necessary.

We recently cared for a young man who had been in an accident in which his right ear was severed completely and later recovered. The skin was removed and the cartilage was embedded in a pocket formed under the postauricular skin in the proper location for the missing portion of the ear. After an interval of two months the reconstruction will be continued as proposed by Kirkham.<sup>8</sup> Any simple primary repair necessary should include every effort to leave the postauricular skin as free of scar as possible so that it may be used later in any necessary reconstructive measures.

Abrasion of the skin frequently accom-

panies other injuries, and if not properly cleaned, may result in an extremely disfiguring scar not unlike a tattoo mark. Such an area should be thoroughly scrubbed with a brush, soap and water. Deeply embedded particles of grime should be picked out with a pointed knife or another sharp instrument. A suitable dressing is very like that applied to a burned area, using a bland ointment. Sandpaper can be used to smooth the surface of an abrasion and remove cinder or powder marks. Dupertius<sup>4</sup> has recently described his method of using small free ear lobe grafts comprised of skin and subcutaneous tissue as a means of replacement of the fat pad of the finger tip.

Painful and disfiguring scars at the fingertips which prevent normal growth of the nail are frequently seen. Douglass<sup>3</sup> has reported a method of repair which he has used successfully. The deformed nail is removed completely and the eponychium is dissected free in the sulcus over the nail root. The scar tissue at the fingertip is undermined, leaving an attachment at either side. An artificial fingernail, such as may be obtained at any cosmetic counter, is inserted under the scar tissue into the dissected sulcus. Sutures are placed through previously drilled holes. The artificial nail is left in place until the new nail has grown under it out over the scar tissue. When the artificial nail is removed the scar tissue band is excised.

Douglass<sup>3</sup> has also successfully replaced the amputated tips of fingers in four patients. Several years ago Gillies suggested embedding amputated fingers in the abdominal wall after the skin has been removed. The finger was to be reattached to the stump and covered by abdominal skin through a series of delayed flaps. The suggestion is offered here in the hope that it might be successfully used in a suitable circumstance.

#### NERVE AND TENDON INJURIES

Tendon and nerve repair should not be attempted unless the wound is seen within

four hours after the injury occurred. When the wound has been previously tampered with (in a physician's office or a company first aid station) even to the ligation of vessels, the wound is closed as simply as possible and a secondary repair is done after healing has occurred. First aid should be limited to the application of a sterile dressing and a splint, bleeding being controlled by pressure or by application of a tourniquet rather than by ligatures.<sup>10</sup>

When the tendons have been repaired complete closure of the skin over them is mandatory. When necessary this may be done with skin flaps<sup>9</sup> or with skin grafts. This is a very important procedure for all surgeons to know—it may save months of time and it may save the function of the hand.

#### FRACTURES OF FACIAL BONES

As a general rule, fractures of the facial bones should be corrected early. Impactions can be broken with relative ease during the first week but the difficulties increase rapidly after a greater interval as does the danger of infection. We have found that repair of maxillofacial injuries does not add risk to the patient with major cerebral, thoracic, abdominal or extremity injury. The exception is if the cribriform plate has been fractured. Immediate facial surgery is indicated for with delay, in addition to tissue loss due to trauma, there is added loss due to infection and retraction. Therefore, as soon as the extent of injury is evaluated and treatment begun the facial repair should be performed.

In our clinic a systematic routine of examination has been adopted. Facing the patient and palpating bimanually the frontal bone is examined for fractures. Then the fingers pass over the supra-orbital rim laterally, around to the infra-orbital rim and back to the nose, comparing the two sides. A displaced zygoma and irregularities of the orbital rim will be immediately apparent. The eyelids are separated and the cornea and conjunctiva are inspected. If there is any visual dis-

turbance, an ophthalmologist is consulted. The nasal bones are next examined for asymmetry or crepitus and the condition of the septum and the lateral wall is determined by intranasal examination. The lips are separated and the teeth are checked for malocclusion and displacement of the alveolar ridge. When the maxilla is fractured movement of the entire compound or fragments can usually be elicited; however, if impaction is severe this may not be possible. Further observations supporting a diagnosis of fracture of the maxilla are widening or lengthening of the middle of the face and displacement of the orbital contents due to loss of support. The examination of the mandible is the last step. After observing the patient's ability to open and close his mouth the temporomandibular joints are palpated, noting the presence of tenderness or crepitus when the mandible is moved. The fingers are then passed down the posterior border of the ramus thence to the body and the mentum. With the thumb within the mouth and fingers behind the ascending ramus holding the jaw firmly, abnormal movement in the mandible may be detected by moving the chin up and down with the other hand.

X-rays of the skull should be routine procedure and although x-rays of the facial bones are usually not necessary they are of great value from a legal standpoint.

A detailed discussion of the treatment of fractures of the facial bones is impossible in a symposium such as this. However, a few important points will be touched upon in the fractures of the various bones.

*Frontal Bones.* Fragments of the frontal bone may sometimes be pried directly into place when the fracture is compounded. Also, the fracture may be approached through the sinuses and the fragments elevated with a chisel. We have on several occasions inserted an ordinary wood screw into the fragment, elevated it by direct pull and where necessary held it in position by attaching it with a wire to a solid arm embedded in a plaster of paris head cap.

*Nasal Bones.* Fractures of the nasal



3. The Straith appliance for treating depressed fractures of the nasal bones includes an adjustable mechanism for elevating the nasal bridge and compressing the sides of the nose. The supporting post is embedded in a plaster head cap.



FIG. 4. X-ray showing maxilla held up by buried, stainless steel wires passed from small drill holes in the frontal process, down behind the malar bone and fixed to teeth in the mouth.

s may be a simple lateral displacement or a crushing fracture of the nasal bones or the maxilla, lachrymal and ethmoid bones. In the first instance, simple elevation can be accomplished with a flat instrument such as a chisel or periosteal elevator. The fragments are molded into position and if necessary the nasal cavity is packed with sterile gauze to support them. There have been numerous methods suggested for the treatment of the more severe crushing fractures of the nose, many of which are satisfactory. We have our own apparatus consisting of two rubber covered metal plates which are inserted into the nares and flat metal pads which may be adjusted to press on either side of the nose. This device is fully adjustable and is supported by a bar on a plaster head cap. (Fig. 3.) The adjusting pressure within the nose can be varied by means of the thumb screws and a universal joint; the pads prevent spreading of the fragments.

**Malar.** Padgett made the statement that fractures of the malar bone without a complicating fracture of the surrounding bones occur rarely.<sup>15</sup> Usually the malar

bone is simply driven in, great force being required to produce this fracture. The pathognomonic sign of fracture is depression of the bone but swelling may make the diagnosis difficult. Distortion of the orbital rim as compared to the uninjured side, anesthesia of the upper lip, the infra-orbital area and side of the nose due to compression of the infra-orbital nerve, together with enophthalmus or diplopia are additional findings aiding in making the diagnosis.

Correction of the deformity is relatively simple if attempted within the first week. Roberts<sup>16</sup> suggested using a screwporte inserted through a small incision to elevate the depressed malar bone. The well known method of Gillies is frequently used—an incision in the temporal skin and fascia is made and a Gillies elevator or a flat chisel inserted downward along the tem-

poral muscle deep to the displaced bone. Lever action over a pad on the side of the head will elevate the bone.

The approach usually used by our group is made through a small incision in the buccal fold opposite the second molar tooth. A Cryer elevator is inserted (a chisel or large hemostat may be used) and the impaction is broken up. The bone may then be wedged into place with external pressure by the other hand. When the anterior wall of the antrum has been crushed it may be necessary to fill the cavity with gauze impregnated with vaseline or tincture of benzoin as support for the malar bone. The packing may be left in place for a week without risk. In badly comminuted fractures wiring of the malar bone to the frontal process is very useful.<sup>6</sup>

*Maxilla.* It has been suggested that surgically the maxillary bones include the malar, the palate, the inferior turbinates, the lachrymal, the nasal, the lateral masses of the ethmoid and the nasal septum, as any or all of these are likely to be involved in injuries characterized as fractures of the maxillary bones. Fractures of the maxillary bones may include the alveolar processes, the palate or the superstructure proper. We do not recommend the use of any method requiring intermaxillary wiring in severe injuries resulting in extreme nasal congestion.

Some of our more recent patients have been treated by the internal wiring method as outlined by Adams.<sup>1</sup> (Fig. 4.) A double stainless steel wire is looped through a drill hole in the infra-orbital rim, if it is uninjured, or through a drill hole in the zygomatic process of the frontal bone. The ends of this wire are passed posterior to the malar bone and into the mouth. If the alveolar process is intact, the wires are attached to the premolar teeth and tightened sufficiently to support the maxilla in its place. When the alveolar process is fractured a silver arch bar is first attached to the teeth and traction is then applied to the bar.

We have also obtained good results with

Fiederspeil's method of passing wire attached to the teeth superiorly and anteriorly through the cheek to a framework embedded in a plaster head cap.<sup>5</sup> This method provides better traction for those patients in whom the maxilla is displaced posteriorly as well as downward but the patient is subjected to the discomfort of the head cap.

*Mandible.* Numerous dental splints have been devised for fixation of fractures of the lower jaw but they are difficult to make and apply. Complete immobilization of the lower jaw can be simply accomplished by wiring the teeth to the teeth of the upper jaw. No external splints or bandages are necessary. When the mandible is edentulous the wires may be passed around the bone and the prosthesis or a molded splint and the intermaxillary wires applied.

In general, fractures of the ramus and the body of the mandible are easily treated by simple intermaxillary wiring. It is generally agreed that fractures of the neck of the condyle are best treated conservatively, with the theory that if union does not occur a false joint will be formed which will function adequately. Padgett<sup>14</sup> stated that when the fracture is high the condyle may be removed and that when it is near the ramus open reduction may be done.

Fractures at the angle are difficult to manage. When the ramus has been pulled too far forward a wire loop may be placed through a hole in the posterior part of the angle and attached by an elastic band to a plaster head cap extending down over the mastoid region.

#### LATER CARE OF FACIAL INJURIES

The procedures useful to the plastic surgeon in the late care of facial injuries fall into four groups and may be used singly or in varying combinations: (1) excision of scars; (2) substitution of soft tissue or bone; (3) camouflage by addition of various substances and (4) artificial internal or external prosthesis.

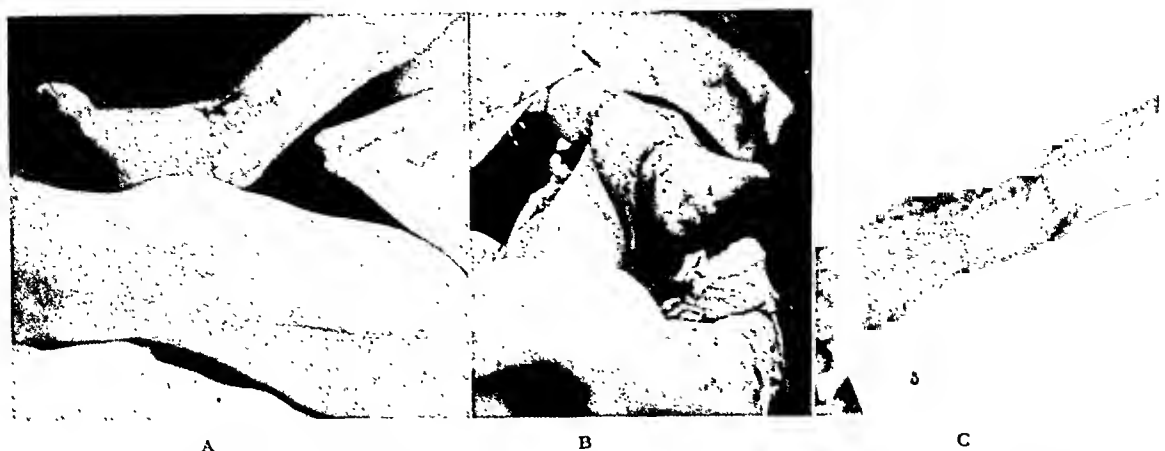


FIG. 5. A, crushing injury with heavy weight fifteen years before resulted in wound shown above which would not heal under usual treatment. Split-skin grafts had not been successful. Flap on opposite thigh has been delayed and is ready for transfer; B, "cross-leg" flap sutured in place before plaster cast was applied; C, healed graft, providing skin which is normal in all respects. Such a graft will withstand trauma better than split-thickness skin grafts.

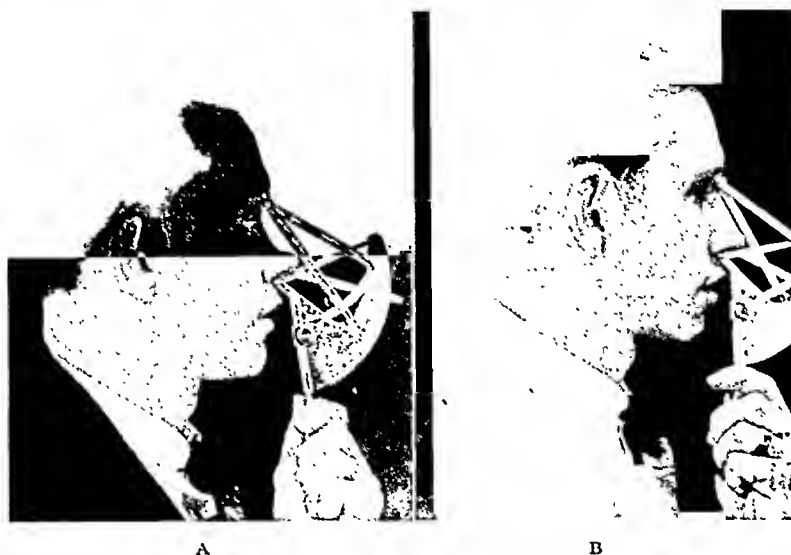


FIG. 6. A, the Straith profilometer, when set at normal, indicates the amount of cartilage necessary to reconstruct the nasal bridge; B, showing normal measurements on profilometer after cartilage transplant.

**Soft Tissue.** All too frequently disfiguring suture marks mar an otherwise satisfactory repair of injuries of the facial skin. They are very difficult to correct for their complete removal necessitates excision of an excessive amount of skin. The careless use of large suture material and failure to remove the sutures early are the primary causes of such scars.

Scars resulting from wounds from which tissue has been lost may be excised and the wound closed in a fine scar if small enough. Such scars have usually contracted severely and the relaxation of the tissues after removal of the scar frequently results in a wound several times larger than the

original scar. Replacement of skin by skin graft, Esser (swinging) flaps from adjacent areas or by tube pedicle from distant areas may be necessary. The transfer of skin from other parts of the body to the face is seldom completely satisfactory since the color and texture is never the same as that of the facial skin. However, the postauricular and neck skin is often quite similar and replacements from these areas are not particularly noticeable.

For the transfer of skin and subcutaneous tissue short distances to fill defects, cover tendons and to replace scar tissue on weight-bearing surfaces, the simple pedicle flap may be used. (Fig. 5.) It is advisable



to skin graft the donor area and the raw surface of the pedicle to decrease the amount of drainage. Flaps may be tubed to transfer tissue to more distant areas.

*Fractures.* Depressions in the frontal bone following fractures are occasionally

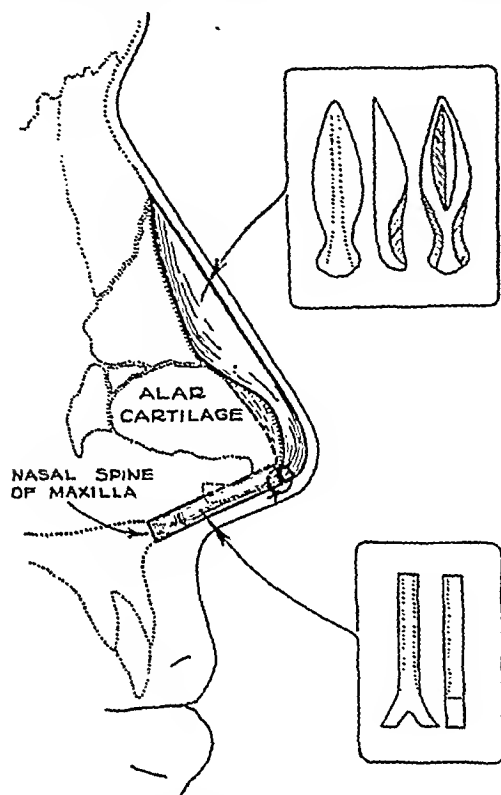


FIG. 7. Drawing showing shape and position of cartilage transplants in reconstruction of nasal bridge. A post for support of the nasal tip is shown resting on the nasal spine of the maxilla.

seen and although they may cause no functional disturbance they are extremely disfiguring. Preserved cartilage can be used to fill such defects, either as a carved solid piece or as diced or pulverized cartilage. An incision is made in the eyebrow or in one of the normal skin creases of the forehead and the skin is elevated throughout the entire defect. It is tedious and difficult to shape a solid piece of cartilage to fit a defect of the frontal bone. When too thin a piece is used it frequently curls and the edges become visible under the skin. The same objection holds with shaved cartilage; therefore, we have been using finely cut or pulverized cartilage, injected into the pre-

pared pocket under the skin with the De-Kleine Chondrajet.<sup>2</sup> The cartilage can be molded into shape after the incision is closed and a pressure dressing is applied to prevent hematoma formation.

Fractures of the nasal bones may result in a marked deflection deformity of the nose, a saddle nose or a hump nose with a depressed tip. A rhinoplasty will correct the deflection deformity or a marked hump on the bridge of the nose. Even in a saddle nose, it is often better to perform a rhinoplasty first, and later to attempt some method of restoring the bridge to normal pleasing proportions. Various methods of reconstruction for saddle nose have been developed, such as the use of autogenous rib cartilage, the use of a piece of the crest of the ilium and the implantation of ear cartilage. O'Connor and Pierce<sup>13</sup> have developed a method of preserving cartilage and have shown that preserved homologous cartilage can be used for such purposes.

For the past twelve years, all saddle nose deformities treated in our clinic have been corrected by the implantation of preserved homologous rib cartilage. Prior to that time autogenous cartilage had been used but one or two unfortunate experiences with the chest wound prompted the adoption of the preserved cartilage transplant.

The Straith profilometer (Fig. 6) is used to measure the amount of depression in a saddle nose and to indicate the shape and size of the cartilage transplant needed. A straight firm piece of cartilage containing no calcified areas is selected. It is cut to the proper length and thickness to form the bridge of the nose. This is inserted through a columella incision into a subcutaneous tunnel along the bridge of the nose. Where necessary a second smaller piece of cartilage is shaped as a supporting post within the columella. (Fig. 7.) This piece has a forked base which will rest upon the maxillary spine, the upper end having been shaped as a tenon to fit into a mortised joint in the first piece of cartilage. The profilometer is also of great value as an



FIG. 8. A, illustrating use of profilometer in treatment of hump nose. The amount of tissue to be removed is measured before the operation, and frequent measurements are taken during the operation; B, postoperative result.



FIG. 9. A, scars of both hands resulting from burns; B, showing result of skin grafts after complete excision of scars.

aid in reducing hump noses to the proper profile angle. (Fig. 8.) It makes the reconstruction of nasal deformities more accurate.

Untreated impacted fractures of the malar bone result in distortion of the facial contours and in visual disturbances. Solid preserved cartilage or diced cartilage may be used to restore the malar eminence.

Healed, retruded fractures of the maxilla may be freed with a mallet and chisel and held in place with proper wiring.

#### BURN SCARS

Plastic surgery as a specialty is more often concerned with the treatment of old healed burns and the resultant disfiguring scars and deforming contractures. Such scars are commonly seen on the anterior surface of the neck, the axilla, the antecubital and popliteal areas, near the eyelids and the mouth and on the face. Severe burns of the hands and feet result in disabling scars. Many scars can be completely



FIG. 10. A, web contractures of both axillae, preventing full use of the arms. The severe contracture has resulted in an ulcerated area on the back; B, restoration of function by massive Z-plasty's. The ulcer healed rapidly after tension was relieved.

excised and replaced by split-thickness skin grafts. (Fig 9.)

The Z-plastic operation is one of the most useful and valuable procedures available to the surgeon in the treatment of scars and contractures anywhere about the body and should have first consideration. (Fig. 10.) Smith<sup>18</sup> has shown the wide variety of uses of this simple procedure and the excellent results obtained with it in his hands.



FIG. 11. Note conspicuous keloidal scars on legs of young girl resulting from unfortunate choice of donor sites for skin graft. When possible, skin should be taken from the abdomen.

Many scars which are too large to permit complete excision and closure in one procedure may be ultimately removed in a number of partial excisions. The normal surrounding skin can be advanced as much as possible, then as relaxation occurs further excision is possible until only a fine linear scar remains.

Cicatricial ectropion of the lower eyelid causes epiphora and irritation of the exposed conjunctiva; ectropion of the upper lid results in lagophthalmus which if marked may lead to loss of the eye. Such deformities can largely be prevented by adequate early treatment of the burn and early skin grafting. The importance of careful consideration in the choice of donor areas should not be overlooked. This is particularly important in young women. (Fig. 11.)

Several satisfactory procedures are available for correction of cicatricial ectropion. The destroyed tissue may be replaced by (1) flaps from the nasal or temporal border of the lid or (2) correction of the defect by full-thickness graft of skin from a normal lid or of skin from the medial surface of an ear. The epithelial outlay of Esser does not produce so pleasing a cosmetic result as does the method introduced by Wheeler, in which surgical adhesions are made between the upper and lower lids after which the graft is sutured



FIG. 12. A and B, Miss M. J. T., aged nineteen, a war worker, had total scalp avulsion when a wisp of hair was caught on a revolving machine. The hair was cut off, and the scalp was replaced by the industrial surgeon and fixed by sutures. Unfortunately the scalp became necrotic as shown here eighteen days after the accident. Four days later the necrotic scalp was removed surgically by us.



C



D

FIG. 12. C, a clean vascular granulation is shown three weeks after removal of the necrotic scalp. The patient is ready for skin grafts. The entire granulating area was grafted at one operation, with thick split grafts united by sutures and clips and rendered adherent to the recipient bed by fibrin fixation through use of Thrombin Topical solution and blood plasma. D, the patient is shown after the operation. The paraffin mesh gauze dressing was fitted snugly over the grafted area and sutured to margins of the defect. No other pressure dressing was required. Patches of pink color may be seen which began to appear over the graft in thirty-six hours.

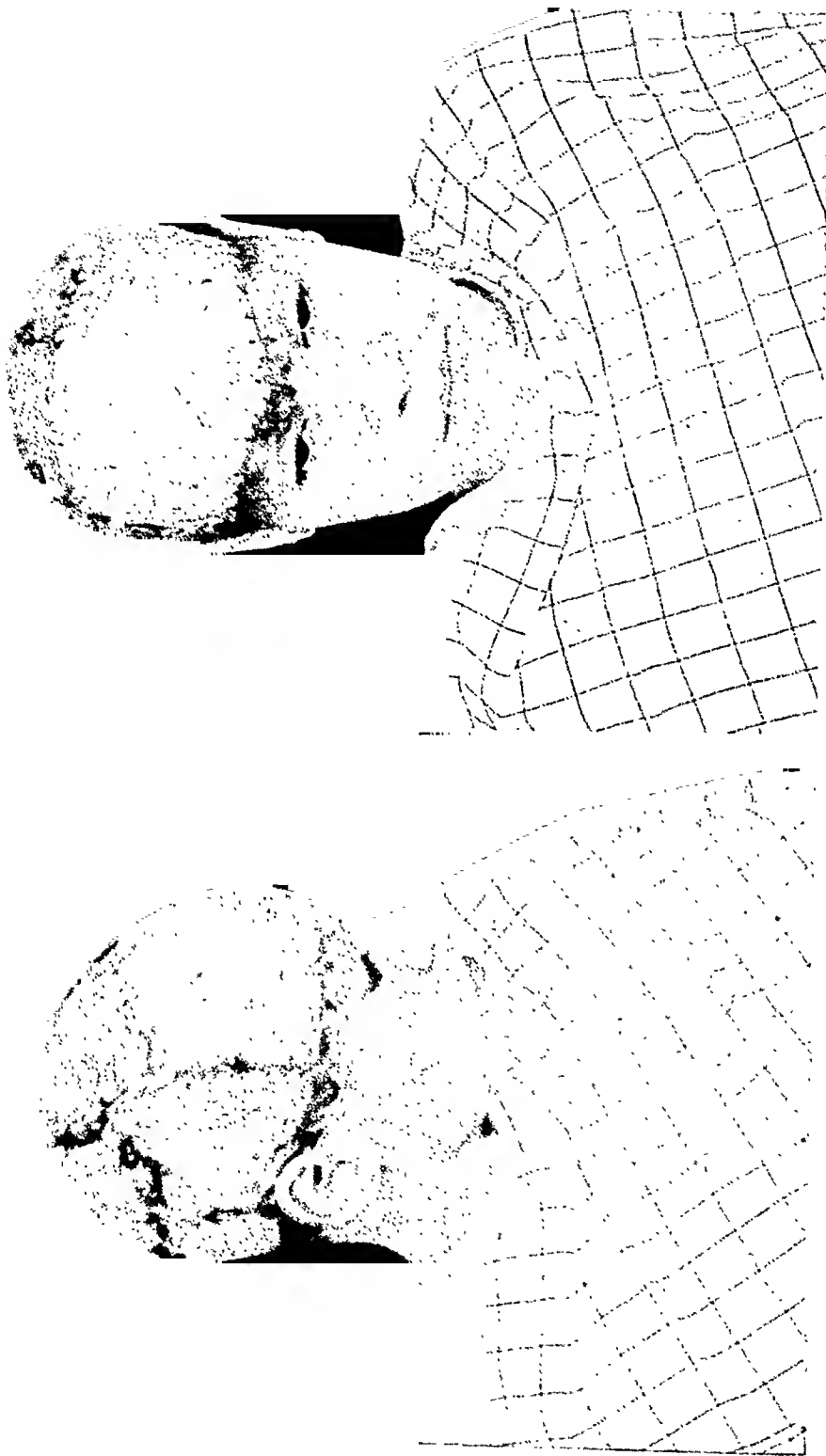


FIG. 12. E and F, two views of the patient are shown on the eleventh postoperative day, immediately after removal of the paraffin gauze dressing. The grafts show almost complete and successful take. Fibrin fixation of skin grafts with Thrombin Topical solution and blood plasma facilitates management of skin-grafted patients and materially enhances the probability of successful results.



G



H

FIG. 12. G, the patient is shown eight months after the operation. The grafted scalp is entirely healed. The graft over the temple was done later when epithelized area was found to be unstable. The new eyebrows were grafted two months after plastic repair of the scalp defect. H, the patient wearing a wig made from the hair which was removed from her avulsed scalp. The total period of hospitalization was only seventy-eight days.





FIG. 13. A, chemical burns caused total loss of the right ear and destruction of the skin over most of the right side of the face. Early skin grafting is necessary to reduce sears and contractures; B, a split-thickness graft was applied to the side of the face. Note heavy sears at margins of the graft and contracture of the right ala. Scar tissue in the region of the ear makes reconstruction of the ear difficult.

in place. The surgical adhesions remain for sixty to ninety days.

Severe burns of the entire face with loss of eyebrows and eyelashes and its associated scars present one of the most heart rending problems in the field of industrial and plastic surgery. The release of contractures, replacement of scar tissue with skin grafts and the necessary trimming and fine adjustments offer a seemingly endless procedure which may continue over a period of years. Although the unfortunate patient will never be completely satisfied it is possible to bring about great changes and improvement. (Fig. 13.)

#### SCALP WOUNDS

A paper dealing with the treatment of industrial accidents would not be complete without some reference to one of the most terrible accidents which may occur in modern industrial plants—the irremediable loss of a young woman's hair through com-

plete scalping. The accident is sufficiently rare that the patient is very likely to fall into the hands of physicians who have never dealt with the condition.

The accompanying illustrations (Fig. 12) show the course of such a patient.<sup>20</sup> A lock of unprotected hair was caught in revolving machinery and the scalp was completely torn away. The scalp was recovered, the hair cut off and saved and the scalp was sutured in place by the industrial surgeon. The entire scalp became necrotic in eighteen days, was removed and the granulating surface was later covered with split-skin grafts held in place by Thrombin Topical\* and plasma.

McWilliams<sup>11</sup> collected forty cases of replacement, all unsuccessful. Since the scalp is a complex organ with an arterial blood supply death is certain when the blood supply is destroyed. Anatomically, simple replacement would appear to be hopeless.

\* Supplied by Parke Davis & Co.



FIG. 13. c, excision of scars has improved the right cheek and mouth. A full-thickness graft was used to release the contracture of the right ala, and a semblance of an ear has been reconstructed from the scar tissue and a tubed pedicle from the chest.

It is suggested that the avulsed scalp be shaved, split and the upper hairbearing surface be replaced as a full-thickness graft. We realize that this theory may not prove practical but if we ever have another opportunity the scalp will be treated in this way. However, the records of the past and the law of averages make this unlikely. We can only hope that this suggestion may help some surgeon to save a human being from similar permanent disfigurement.

The wearing of hair nets by women employees should be mandatory.

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# RECONSTRUCTIVE SURGERY OF THE INJURED NAIL

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THE importance of the hand has been compared with that of the brain in human economy. However important may be the brain, the functional efforts consummated by the hand are so imperative for maintenance of life and the creation of new things of life that the hand makes a fair bid for the supreme station. As life becomes more and more industrialized the uses of the hand become more manifold and highly specialized. It is natural also with the increased use of the hand and the increased speed of modern industry that the hand is liable to more frequent injury than any other part of the body. Industrial injury demands immediate consideration of the states of present and future disability. In other words the full mechanism of workmen's compensation is placed in motion. It is to the employee's, employer's and the insurance carrier's benefit to get the worker back to work with as little permanent disability as possible in the shortest period of time.

Most states have set up elaborate schedules and fee tables to cover most all traumatic work; however, there is no state at present that recognizes deformity or loss of a nail as a disability, either partial or total. A disability may be defined as "the inability to work with the same degree of ease and comfort as before the injury was sustained." Only two states recognize disfigurement of the hand as a compensable disability. If the injured digit is considered when all joints are functioning and the nail only is deformed or a vestige of its former self, it would require a very callous referee and doctor to swear there is no permanent disability. There is a disability, especially if the hand has been trained for delicate precision work or if it is employed in the arts of acting or modeling. It is certain that

the ever present disfigurement as well as the dysfunction initiates the verdict of a permanent disability. Any procedure that will tend to eliminate a possibility of even a 1 per cent permanent disability result in one, a much more satisfied employee, two, less expense to the insurance carrier and three, better work at less expense to the employer.

In the past surgery of the nail has not been extensive. Ingrown nails and paronychia were drained. Lacerated nails were usually permitted to heal as best they might. In the last twenty years there have been only four papers published in American medical literature concerned with surgery of the nails.<sup>1-4</sup> There is only one textbook of surgery that in any way discusses reconstructive surgery of the nail.<sup>5</sup> Reconstructive surgery of the nail may be divided into two groups for the purpose of discussion; first, the immediate repair of the damaged nail and second, delayed or secondary repair of the injured and/or deformed nail.

## IMMEDIATE REPAIR

Of the various injuries that might occur to the nail the least severe is a subungueal hematoma following direct pressure on the nail, such as a blow with a blunt object or the squeezing of a finger tip between two hard objects. Most usually the hematoma is small and self-limited; however, the period of disability is lengthened if the presence of the pain factor is prolonged. Early trephine relieves the pressure and eliminates the pain almost instantaneously. Recovery is facilitated, for less separation of the nail plate from the matrix occurs. The nail plate reattaches itself to the matrix much as a split skin graft if the trephine is carried

out early. The patient may return to work immediately with a small pressure dressing over the nail.

Lacerations of the nail may be longitudinal, transverse or one of many oblique types. The oblique lacerations are by

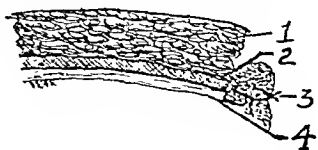


FIG. 1. The pressure dressing of sponge rubber (1) and metal heet (2) on the nail graft (4). The approximation of the skin edge to the edge of the nail graft with mattress suture (3).

far the more common. There is little difference in the procedure of repairing the different types. With the nail that is split longitudinally, frequently there is no injury to the matrix other than a small superficial tear that frequently does not pass through the stratum germinativum. Careful, accurate approximation with sutures after the method of Carter<sup>1,2</sup> insures good results. In this method small holes are bored in pairs near the free border along either side of the split. A fine wire suture is threaded through each pair of holes and tied tightly, so that the split or laceration is thoroughly approximated with two or three interrupted wire sutures. It has been noted that in addition to the above fixation a piece of metal sheet, such as tantalum cut and shaped to fit the nail plate, will maintain vertical approximation much more perfectly. Such perfect approximation will limit the scar formation, which will in turn eliminate nail deformity. The metal sheet protects the nail from injury due to bumps and permits an even pressure to be applied. This will permit the employee to return to work much sooner.

In the transverse and oblique lacerations there is usually other soft tissue injuries. The extent of the débridement governs the reconstructive procedure. In patients in whom little or no débridement is required careful, accurate approximation of the

fragments may be instituted. After complete hemostasis has been effected the soft tissues are sutured through the skin only. Deep sutures are not required about the finger tip. The nail fragments should very nearly fall into approximation; however, close approximation can only be insured by suturing the nail plate. This is accomplished by boring small holes in pairs along either border of the laceration. These holes must be exactly opposite one another. They are bored on a slant from a point 1 mm. from the edge of the laceration to a point almost at the edge of the laceration on the under side of the nail plate. In this way the existing matrix is not traumatized. Again a metal plate is fitted to the nail and a small pressure dressing is applied. The sutures are not removed. The free border of the nail is kept closely clipped. The metal plate is worn until the laceration has grown out to the free border. The period required for this growth naturally depends on the site of the laceration. However, the employee can usually continue his work throughout this period.

Avulsions of the nail may be treated in one of three ways. If a distal portion of the nail is lost without extensive matrix damage, a piece of metal sheet is cut and shaped to simulate the lost portion of the nail after the distal end has been cut smooth with a sharp scalpel. The thickness should simulate that of the nail plate. This portion is then bent upon itself so that the remainder of the piece is shaped to fit the whole nail plate. As the nail grows out this plate is pushed ahead. This method is only efficacious in those patients with an avulsion of the small portions of the nail. If the avulsion is extensive with minimal matrix damage, the remaining edge of the nail is straightened by a perpendicular cut with a sharp scalpel. A nail graft is raised from another nail and used to replace the avulsed portion. The procedure of nail grafting is discussed under that subtitle. Occasionally, this procedure will necessitate lost time; however, the lost time will be less than that required for healing without the graft and

the healing will be more perfect. The possibility for infection is decreased. The possibility for permanent deformity is greatly minimized if not completely eliminated. In those patients with an injured matrix a meticulous débridement is effected

into the hands of a surgeon acquainted with nail surgery, the need for secondary reconstruction will be limited to those patients with partial amputation, infections and severe avulsed contusions. There are a few complications that occasionally follow the

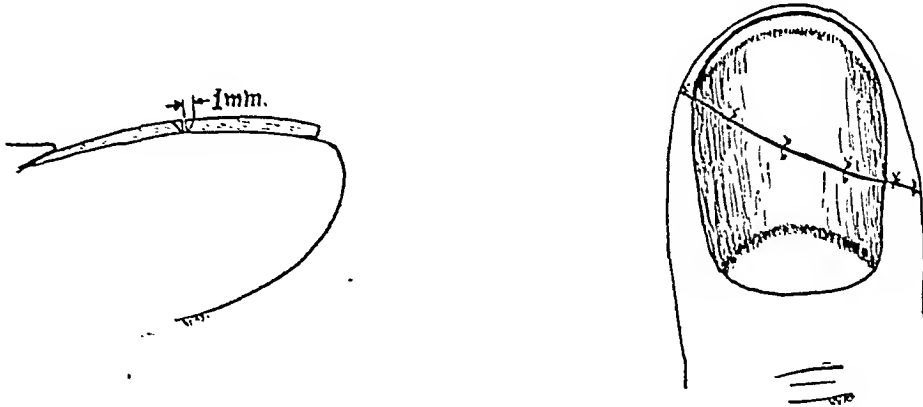


FIG. 2. The suture of the lacerated nail.

so that the resulting area is smooth enough to receive the nail graft. Such débridement may, if necessary, be carried down to the extraperiosteal tissue about the distal phalanx. If the new bed is smooth the nail graft will stand an excellent chance of remaining viable.

The partial amputation, involving the tip of the finger and the nail tissues, may be treated as an amputation by closing the end or as a reconstructive problem by skin and nail grafting. Usually the skin graft is an immediate procedure. The nail graft is effective after the skin graft has taken. At this time the area that was previously the site of the nail bed is prepared for the nail graft. The nail tissues that remain are cut to accept the graft. The skin of the graft is shaved down to the stratum papillosa or about  $\frac{20}{1000}$  of an inch of the superficial skin is removed. When a smooth bed has been prepared the nail graft is transplanted as in the procedure of nail grafting to be described.

#### DELAYED REPAIR

The secondary reconstruction of the nail may be undertaken any time that the tissue of the individual patient seems to be ready to accept this reconstruction. If the initial repair or traumatic treatment falls

initial reconstruction which will necessitate some minor adjustments. Pterygium of the nail is seen as a sequellae of faulty healing of longitudinal lacerations. The cuticle adheres to the scar tissue and extends distally over the nail in a triangle. The condition may be averted by constantly pushing back the cuticle during the healing process. If the condition is present, an incision is made through the base of the pterygium down to the nail plate at the normal site of the cuticle. The pterygium is then shaved off the nail plate. Bleeding is controlled by pressure. Persistent attention is necessary to maintain the cuticle thereafter until the nail is fully healed. In those patients with a broad nail scar it may be necessary to excise the scar in order to get permanent healing without deformity. The repair of the nail following the excision of the scar follows the technic previously described for the repair of longitudinal lacerations.

Split nails are treated like longitudinal lacerations. If a matrix scar is present it must be excised in order to have a good cosmetic result.

The next most common sequellae of nail-trauma is onychauxis. In certain patients the cure of this hypertrophy has been effected by removal of the nail with per-

sistent trimming of the new nail as it grows. However, the more accurate method of nail removal followed by nail grafting<sup>6</sup> facilitates recovery, shortens the period of disability and eliminates permanent disability settlements.

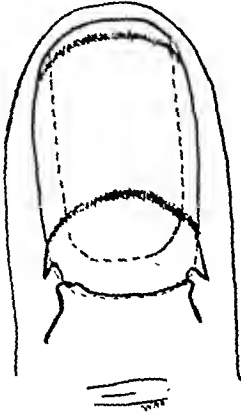


FIG. 3. Nail grafting; the donor nail with the cuticle retracted; the graft is laid out with dotted lines.

Reconstruction of a nail may be undertaken as soon as the other soft tissues of the finger tip are free of infection, have a good blood supply and are free of any devitalized tissue. It is necessary to remove any deformed nail plate. The matrix is preserved as much as possible, particularly the root matrix; however, all scar tissue must be removed before an acceptable bed is prepared for the nail graft. If, in the excision of the scar tissue the viability of portions of the matrix is jeopardized, this matrix tissue must be débrided. The recipient bed must be smooth. The presence of matrix is unnecessary but very helpful as it aids in the maintenance of regular tissue sequence. If the removal of scar tissue demands it, the matrix and reticularis unguis tissue may be excised down to the extraperiosteal connective tissue. The one imperative requirement is that the recipient bed thus formed is smooth, so that the semirigid nail graft will be given complete approximation with the bed at all points. If the lateral nail sulci are not present, tissue folds can be created so that the freshened edge of the skin will fold in to

approximate itself with the edge of the nail graft. The graft which has been raised from the donor site is brought over and placed upon the recipient area.

#### NAIL GRAFTING

The technic of nail grafting<sup>1-6</sup> is not a difficult one. It follows the same principles as split thickness skin grafting; however, because the graft is semirigid certain special conditions must be met. These are a perfectly smooth recipient surface and a definite pressure dressing.

The preparation of the recipient site is described above. The recipient site is prepared when a perfectly smooth bed is consummated, irregardless of what tissue must be sacrificed.

The donor nail is chosen from the finger or toe where the nail most nearly conforms to the original nail. Upon careful observation it will be noted that the nail of each finger and toe is different in convexity, length and breadth. Although it is not essential, it can be readily appreciated that the best nail to use as a donor is the corresponding nail of the opposite extremity. The donor nail is prepared so that the finger and nail are surgically clean. The size of the graft is laid out on the nail. The graft is made as large as possible. A strip of nail about 2 to 3 mm. is left on the lateral aspects in order to maintain the width of the nail as the new nail grows and to prevent the formation of an ingrown nail. As nails do vary in thickness the suggested width is arbitrary. Enough nail plate should be left so that it will be strong enough to lend the desired support. The proximal end of the graft should reach proximal to a little more than half of the lunular nail plate. The graft is freed from the matrix by dissection and transferred to the recipient site. It is imperative that the recipient site is dry. The coagulum contact method of graft adhesion is employed. Redisolved commercial plasma and thrombin is used with success. The skin edges are brought in contact with the graft. If a new bed has been made or a loss of sulcus wall

is present, the skin edges are rolled underneath themselves to form a new sulcus. This is maintained by mattress sutures. (Fig. 1.) The graft is supported with a covering of tantalum sheet (0.0025 of an inch) that is cut and shaped to exactly fit the graft. Pressure is applied to the graft through the tantalum sheet with a sponge rubber pad and bandage. (Fig. 1.) The sponge rubber pad is cut to fit the graft. The thickness should be about  $\frac{1}{4}$  of an inch. The donor area is dressed with a similar dressing.

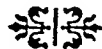
The postoperative care simulates that for skin grafting. The dressing is changed on the tenth day unless a morbid aroma arises suggesting death of the graft. The dressing is changed immediately if there is any evidence of drainage. A pressure dressing should be maintained over both recipient and donor areas for approximately one month. However, if the nail requires further protection the dressing should be continued. Occasionally, small outgrowths of granulation tissue appear about the periphery of the nail graft. This will occur if the skin edge and graft edge have not been accurately approximated. The outgrowth is cauterized with a silver nitrate stick. After the nail grows out it should be trimmed short at its free border with a very sharp scissors or nail clip without applying pressure on the nail plate.

The scientific explanation for the advantages gained by the use of the tantalum sheet in many of the described procedures is a bit obscured. However, it has been found that its use facilitates the more normal regeneration of the nail plate. Probably it acts as a trellis to direct the growth. In some patients an early tendency to hypertrophy will be noted. A very mild dose of x-ray will tend to curb this excessive growth. A course of six very light treatments are usually used with the radio-sensitiveness of the matrix tissue borne in mind.

It is believed that with these few techniques added to the armamentarium of the industrial surgeon that a distinct percentage of permanent settlements may be erased.

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# INJURIES TO THE ABDOMEN IN INDUSTRY\*

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IT is fortunate that with improved safety precautions and education injuries are less frequent in industry than a decade or two ago. The nature and extent of surface injuries or injuries to the extremities are usually obvious; those involving the abdominal viscera are less likely to be recognized early.

In discussing abdominal injuries the nature of the etiologic factor plays a major rôle in formulating our plan of treatment and aiding us in diagnosing the extent of probably intra-abdominal injury. Therefore, the exact history of the nature of the injury is highly important. In evaluating an injury of the abdomen one should inquire into the past medical history to determine if any pre-existing intra-abdominal lesion could play a part in the present clinical picture. This is especially important from the medicolegal standpoint as it may have bearing on the compensability of the alleged accident, not for the immediate period alone but for the future as well.

Cutting or tearing injuries of the abdomen are rare in industry and usually involve only the abdominal wall. Heavy moving objects or crushing objects are the most common etiologic causes of intra-abdominal injuries. Penetration of the abdominal cavity by small or cutting missiles, while not common in industry, require mention because often what appears to be an insignificant surface lesion may involve the viscera. Probing or examination of the wound is of no value in determining the depth of the wound if the wound extends to or below the superficial fascia of the abdominal wall, since the mobility of the various muscles and fascia layers does not permit following the course of the missile. There is but one way to be

sure that the peritoneum has not been penetrated and that is to inspect it which requires that it be exposed surgically.

Occasionally, due to strenuous exercise there may be hemorrhagic infiltration of the abdominal wall without any direct trauma. This was seen during the training maneuvers of World War II and simulated acute appendicitis. Fruin and McLaughlin reported on fifty-one patients, 96 per cent of whom were affected in the lower portion of the rectus muscle. Ten of these patients had palpable hematomas on admission to the hospital. Since 86 per cent affected the right side appendicitis was easily confused with the cause and interpretation of the symptoms and findings. Treatment of this type of injury consists of rest and the hematoma and soreness will subside rapidly.

Because of the mobility of most of the abdominal viscera, trauma applied slowly is less likely to cause rupture of a viscus than are sharp sudden blows. A distended hollow viscus is more likely to rupture than one that is empty, while a hollow viscus which is the site of a pathologic process such as an ulcer or a diverticulum might be expected to rupture easily. Such a locus of a rupture is actually rare and nearly all patients with a ruptured hollow viscus whom we have seen have had ruptures through normal appearing structures. All intra-abdominal hollow viscera are not intraperitoneal and this might cause some confusion in diagnosis if not properly considered. Notably, the duodenum, the ascending colon, the descending colon and the bladder are extraperitoneal. Not only are these structures extraperitoneal but they are relatively fixed structures and do not move freely when force is applied.

\* From the surgical service of The Detroit Receiving Hospital, Wayne University College of Medicine and The Michigan Mutual Hospital.

The root of the mesentery of the small bowel is also relatively fixed and is likely to be bruised from crushing injuries. Solid viscera, the liver, spleen, pancreas and kidney are moderately fixed structures but have sufficient mobility and compressibility that fairly well tolerate slowly applied pressures. The application of pressure applied suddenly is more apt to cause rupture of these structures, especially if they are enlarged, than an even greater pressure applied gradually. The viscera of young people appear to stand trauma better than in the older age group.

The diagnosis of serious damage to intra-abdominal structures is not usually possible immediately after the accident. The effects of a severe blow to the abdomen usually causes a great deal of disturbance immediately and soreness in the abdomen is likely to persist for some time even when no serious intra-abdominal injury is present.

The fact that the patient appears to recover quickly from a severe blow to the abdomen does not rule out a serious intra-abdominal injury, since quite often the patient will appear to recover from the immediate effects of trauma to the abdomen but will develop signs of visceral injury later. The following is an illustrative case report.

#### CASE REPORTS

CASE 1. L. J., aged forty-five, a maintenance man, was engaged in sawing a piece of wood which caught in the blade and was thrown against his abdominal wall. At first, he did not think he was hurt but soon he became nauseous and noticed severe pain about the genitals and rectum with pain later in the abdomen. He was admitted to the hospital five hours after the accident. The physical examination showed no surface evidence of trauma but the abdominal wall was rigid. An operation seven and one-half hours after the accident showed a tearing of the ileum.

Accordingly, such a patient should be kept under observation or advised to report immediately after the first evidence of abdominal pain or nausea, weakness or

shortness of breath on exertion. It is not unusual for a ruptured hollow viscus to result in delayed signs or symptoms for several hours. Those from ruptured solid viscera may be delayed for days or weeks.

Following injury to the abdomen the development of rigidity or acute tenderness is an indication for exploratory laparotomy if other signs or symptoms support the diagnosis of a ruptured viscus. The x-ray is an important adjunct to diagnosis. In all instances a supine and upright flat film which includes the diaphragm are essential.

Two important conditions for which operation is not indicated at this point, which may simulate a ruptured viscus so far as signs and symptoms are concerned, may be definitely diagnosed by the x-ray. These are ileus and acute gastric dilation. The latter usually follows immediately after the injury and may persist for some time; the former usually occurs some hours after the injury. Acute gastric dilatation is easily recognized by x-ray, the supine film revealing a large gas shadow outlining the stomach, the upright film is a fluid level. In patients with severe prostration, cyanosis, abdominal pain and tenderness, increased pulse rate and decreased blood pressure may be present and can simulate a severe abdominal lesion. Those patients with milder degrees may be associated with no more than abdominal discomfort and nausea. The treatment is obvious decompression by means of a nasal catheter and reassurance of the patient is usually all that is required. Ileus, frequently an associated condition in retroperitoneal injuries, is best treated by intestinal intubation and suction drainage.

In those patients with a ruptured hollow viscus the most common sites are the jejunum, duodenum and colon. Rupture of the bladder is not uncommon in association with fractures of the pelvis and the tear in the bladder is usually extra-peritoneal. It is strange that the cecum which usually contains a fair amount of gas is so infrequently ruptured. The colon which is so commonly the site of diverticuli

and usually contains gas might be expected to be more frequently ruptured. That is probably due to its large capacity which permits a freer movement of the gas.

X-ray findings in rupture of the intestinal tract are diagnostic early in more than half the patients; later, almost all will show some gas beneath the diaphragm if the tear is intraperitoneal and of any size. The fact that there is air beneath the diaphragm gives one no indication as to which portion of the gastrointestinal tract is involved. The finding of diffuse scattering of air in the retroperitoneal tissues is much more helpful in localizing the site of a ruptured hollow viscus. In rupture of the duodenum this is a dependable localizing sign. Fine diffuse mottling of gas in the subhepatic area or along the psoas line, especially on the right side, is quite unlikely to come from any place but the duodenum. This retroperitoneal extension of gas may be so extensive that it actually reaches the pelvis and the flat film may show a foamy appearing line from the area of the duodenum to the pelvic brim or lower; when it is present the film is diagnostic. The following case report illustrates such a condition.

CASE 11. A. S., a twenty-seven year old black male, an employee of a concrete company, fell one story and the air-hammer which he had been using fell on his abdomen. Initial x-rays were not diagnostic. Films made a few hours later, however, revealed definite, large numbers of small vesicles of air in the retroperitoneal space as has been described. An exploratory operation was performed and the duodenum was found almost completely divided at the junction of the second and third portions. The duodenum was repaired and the patient made an excellent recovery.

In our experience rupture of the jejunum is not uncommon. One might expect to find the rupture near the fixed portion of the jejunum but in our series this was not always the case. Usually, however, the tear is found in the first 2 feet of the jejunum. The following case is illustrative.

CASE 111. J. W., aged twenty-seven, a pattern worker, was struck in the abdomen by

a board about 10 A.M. and reported to the plant hospital. The pain was not severe so he returned to his home whereupon, he noticed some pain in his abdomen when he drank some broth; this was vomited almost immediately. He was admitted to the hospital about six hours after the accident. The physical examination showed a well nourished white male, with an anxious look on his face. His respirations were rapid. The abdomen was board-like and extreme pain was apparent on the slightest pressure. At the site of a slight abrasion to the left and below the umbilicus the pain and tenderness was more intense. The abdomen was tympanitic and the liver dullness partially obliterated. At operation ten hours after the accident, free brownish fluid resembling broth escaped from the peritoneal cavity and the presenting segments of the distended small intestine showed a plastic exudate. The point of laceration was about 1 foot distal to the ligament of Trietz and was large enough to admit the little finger. It was repaired with interrupted plain and fine chromic catgut sutures fixing the omentum at the site of repair.

While rupture of any hollow viscus is likely to result in peritonitis, those tears found in the large bowel are particularly hazardous and require early laparotomy. While this is what one would expect, it is worthwhile to point out that we have seen several patients in whom gas escaped into the peritoneal cavity from a small opening in the colon, which caused a massive right subdiaphragmatic collection of gas and only a localized well walled-off abscess resulted.

The solid viscera most commonly injured in trauma to the abdomen are the liver and spleen. The result of rupture of either of these structures is that of severe loss of blood. Smaller tears in the liver may result in but a small loss of blood before clotting occurs. This is not usually so in a patient with splenic rupture. Even small tears in the spleen may continue to ooze blood over a long period, so that the first outstanding feature which calls attention to the seriousness of the injury is severe anemia. Larger tears are more likely to present the picture of acute blood loss. We have had little suc-

cess in repairing such rents and find it far simpler to remove the traumatized spleen. Massive tears in the liver likewise result in acute blood loss. In such patients suture of the rent is usually possible, especially with oxidized cellulose or gelatine foam as supports for the suture to aid in the prevention of tearing, as well as the use of these substances in conjunction with thrombin to control bleeding. In massive tears of the liver the possibility of bile peritonitis is a threat and in those patients in whom there is any question of poor approximation of the torn liver it is wise to drain. It is rarely necessary to pack the rent in the liver with massive gauze packing as the absorbable material is more effective and simpler to use.

Traumatic peritonitis can result when there is no wound in the abdominal wall and the peritonitis is free from bacterial contamination. The solid organs are more likely to be injured from a blow than the hollow organs. If the bladder is injured with leakage of urine into the peritoneal cavity, a severe peritonitis results. Bile leaking, likewise causes a severe peritoneal reaction. Blood in the peritoneal cavity may be absorbed and cause little reaction but if it clots and the fibrin holds the cells, peritoneal adhesions usually result.

Rupture of the pancreas is quite likely to be overlooked and small tears may result in a cyst formation, to be discovered at some time remote from the accident. The head of the pancreas or that portion lying over the spine is most likely to suffer from crushing injuries. It is in this portion that the ducts are larger and may actually result in great losses of pancreatic juice, especially following drainage of a resulting abscess. The following is an illustrative case.

CASE IV. B. M., a forty-one year old white male, was admitted to the hospital July 11, 1946, thirty minutes after being crushed between the back of a truck and a loading platform. On admission the patient was in severe pain but had no shock. Immediate x-rays revealed free peritoneal air, fractured transverse

lumbar processes and one spinous process of a lumbar vertebra. The patient also had bilateral fractured acetabulae and separation of the right sacroiliac joint. Immediate exploration under general anesthesia revealed a stomach which had been sectioned at the pylorus. The pancreas was bleeding freely and there was a large rent in the mesentery and the ligament of Treitz. A subtotal gastric resection was performed. The pancreas was packed with oxycel gauze and the mesentery of the small bowel repaired. The patient made an excellent recovery, being discharged in fifteen days. He was back at work in five months.

Rupture of the receptaculum chyli is not a common injury. Usually following this injury there is severe upper abdominal pain and pain in the back. The lesser peritoneal sac may become markedly distended with lymph, and if this is drained, the lymph may drain to such an extent and for such a time that it will cause serious problems in water balance and nutrition. It is difficult to find the opening in the lymph channels. When possible to find the lymph seeping through a rent, it usually suffices to close the surrounding tissues over the area. As a rule, however, packing the area until scar can form to close the defect is the best that one can do.

#### CONCLUSIONS

Intra-abdominal lesions resulting from industrial accidents are serious problems. The recognition of such lesions is not always easy. Unless the patient is carefully observed with signs and symptoms properly evaluated, the true nature of the intra-abdominal lesion may be overlooked.

It is important in every injury to a patient involving the abdomen, to obtain a careful history and physical examination and the circumstances concerning the accident should be accurately recorded, since in many instances intra-abdominal lesions may develop subsequent problems, not only of a medical nature but of a legal nature as well.

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# INJURIES INVOLVING THE GENITOURINARY TRACT\*

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SINCE cessation of hostilities in World War II, several reports have appeared regarding war injuries to the genitourinary tract. Most of these articles have appeared in the Journal of Urology. Barring penetrating wounds (gun shot and shell fragments) and lacerations of the external genitals due to land mines, etc., it would seem that there is little difference in the management of the injuries to the genitourinary tract in civil and military practice.

In industry injuries to the genitourinary tract are relatively uncommon and will be considered under the following headings:

(1) Lacerations of the external genitals, (2) prostatitis and epididimitis following general body trauma, such as falls, blows, etc., (3) lacerations of the urethra—pendulous, bulbous or prostatic, (4) bladder and (5) kidney.

*Laceration of the External Genitals.* These lacerations have been extremely rare. It is very important to save all penile and scrotal skin and do a minimum amount of débridement as the regenerative powers of this skin is very great. In the end results this is seen in the urinary extravasation when large amounts of scrotal and penile skin have been destroyed.

## CASE REPORTS

An airdrill tangled in a patient's trouser leg and tore off most of the scrotal and penile skin, leaving the testicles hanging free with the blood supply undamaged. The testicles were buried in the perineum and covered with the remaining scrotal skin. The skin of the thighs was stitched together in the midline and the prepuce was stitched back to the skin of the abdomen at the root of the penis. The wound healed mostly by first intention. At the end of three months there

had been sufficient regeneration and stretching of the penile and serotal skin to produce almost a new serotum. The anticipated plastic to construct a new scrotum was unnecessary.

In the case of another patient a cylinder head explosion caused hematoma of the penis resulting in impotence. A cylinder head compressor blew off and just "dusted" across the anterior surface of the abdomen and thighs. There was a slight laceration of the prepuce and hemorrhage into the corpora. The end result was several indurated areas in the shaft of the penis resembling Peyronie's disease as well as impotence.

*Strains Due to Slipping.* Direct trauma to the scrotum and lower abdomen are often followed in a few to twenty-four or thirty-six hours by frequency, hematuria and scrotal swelling (epididimitis). These usually resolve under rest in bed and chemotherapy. The epididimitis is often resistant and disability is usually shortened by an epididymectomy. Almost invariably in these patients there is pus in the prostatic secretions. There may be no urinary symptoms. Usually there is pain in the groin preceding the scrotal swelling, the inference being that the trauma lights up a pre-existing prostatic infection which extends down the Vas involving the epididymis.

*Laceration of the Urethra.* Laceration of the pendulous urethra is rare and has been seen only in knife wounds or fracture of the penis in erection.<sup>2</sup>

*Bulbo-membranous lacerations* are straddle or "crotch" injuries due to falling astride a beam, one leg down an opening (manhole<sup>3</sup> or loading dock), a wrench handle blow to the perineum, etc. Figure 1 shows the triangular ligament and the fascias which determine the direction of the

\* All cases are the writer's private cases unless otherwise mentioned.

extravasation following the laceration of the bulbous urethra. Free bleeding from the meatus independent of urination is the presenting symptom. There may or may not be acute retention of urine and there may be extravasation into the tissues with very

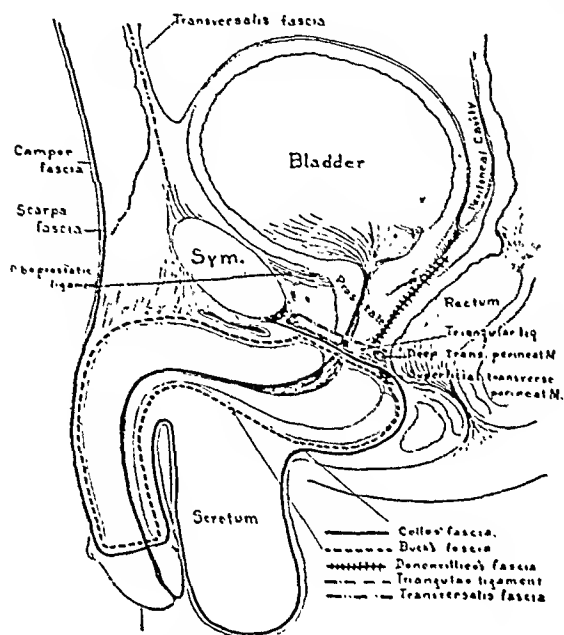


FIG. 1. The fasciae of the penis and scrotum are important as they control the direction of the extravasation of urine. Particular attention is directed to the triangular ligament (after Wesson<sup>1</sup>).

little bulging. (Fig. 2.) In management, first try to pass a fair sized soft, rubber catheter, No. 20 or 22 double eye or a Foley catheter; if successful, tie in. This serves as an internal splint and should remain *in situ* for five to ten days. If unsuccessful, gently try a No. 24, a 26 F sound or a catheter on a stilet. This may "iron out" the ragged edges and permit the passage of a soft rubber catheter. Do not use small, rigid instruments as they catch in small pockets. Do not spend much time "poking" around in an effort to pass the obstruction, thereby, increasing laceration and spreading infection. Do not wait a few days and try again as strictures form rapidly and soon become filiform requiring treatment and often operation. If still unsuccessful, perform a suprapubic cystotomy and try Davis<sup>4</sup> interlocking sounds or a retrograde catheter. (Fig. 3.) If unsuccessful and the condition of the patient



FIG. 2. Urethrogram in a "crotch" trauma; suprapubic cystotomy. Davis interlocking sounds are not successful. The catheter is passed retrograde and a second catheter is attached to it and drawn back into the bladder. Later a peritoneal hematoma was evacuated.

warrants, put him in a lithotomy position and do a perineal section on the beak of a sound or Wheelhouse staff, (Gibson<sup>5</sup>) pick up the retrograde catheter and thread a catheter through the urethra into the bladder. Close the perineum loosely and drain suprapubically for a few days. Leave the inlying catheter ten to fifteen days. If the patient's condition is such that perineal section should not be attempted in addition to cystotomy, go back in two or three days or as soon as his condition warrants, trying a retrograde first and then a perineal section. Continuity of the urethra must be established and now is the time to do it. If postponed it is necessary to excise the scar and probably do a plastic. (MacGowan,<sup>6</sup> Cabot<sup>7</sup> and McLean and Gerrie.<sup>8</sup>) Postoperative sounds are necessary indefinitely because if neglected almost certain formation of stricture will arise.

Injuries involving the *prostatic urethra* and tearing off of the prostate at the apex, or lacerations through the prostate almost invariably are the result of injuries with

fractures to the pelvis. (Fig. 4.) There is usually shock, bleeding from the urethra and urinary retention. There is a tenderness and some fullness in the suprapubic area and within a few hours following injury there is considerable ileus present. Cathe-

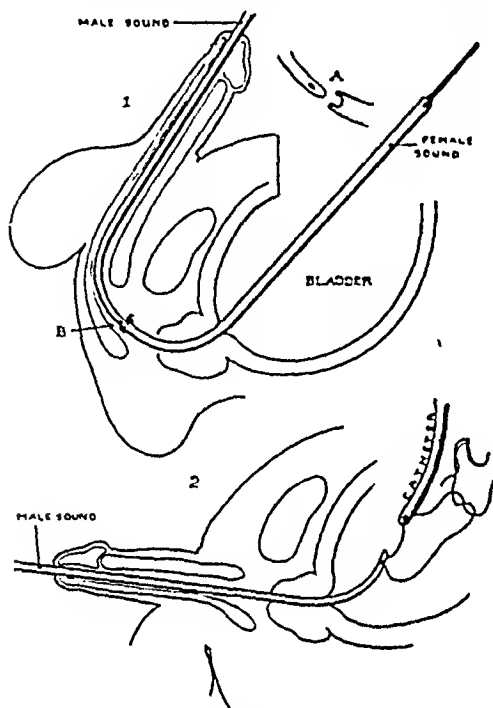


FIG. 3. From Davis's original article describing interlocking sounds for use in ruptured urethras.<sup>4</sup> No. 1 shows male sound introduced via meatus of the penis to the site of rupture of the urethra, B, and engaged in the cupped end of the female sound introduced via the bladder. A demonstrates the cupped end of female sound and tip of male sound with a hole in it. No. 2 is the male sound with a suture through hole at tip which is ready to pull the catheter from the bladder through the penis.

terization is impossible or misleading, (Fig. 6) the catheter passing into a perivesicle pocket. It may drain urine at first but infection sets in shortly. This type of drainage should not be attempted. Appropriate treatment of the shock if present should be carried out, following which x-rays of the pelvis should be made. A soft rubber catheter may be passed and a contrast medium injected. Figure 5 shows the extent of extravasation. This is probably unnecessary as the diagnosis of ruptured urethra has already been estab-

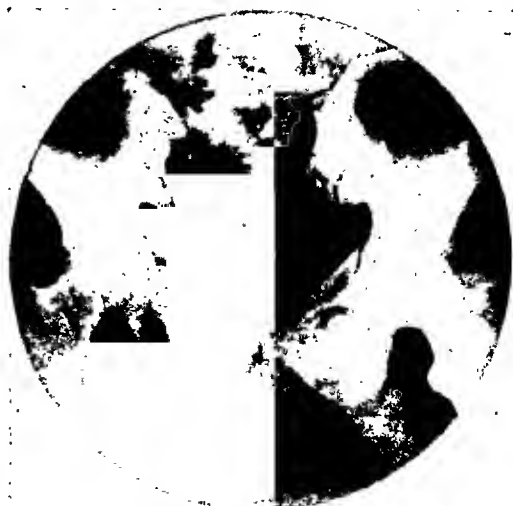


FIG. 4. Fractured pelvis with crushing injury. The patient was crushed between bumpers of two railroad cars. This is a type of pelvic fracture producing varying degrees of laceration of prostatic urethra with extraperitoneal extravasation of urine and hematoma, as shown in Figures 5 and 6. The displaced fragment produces a shearing or tearing (partial or complete) of the prostatic urethra. A urethral catheter drained blood and urine. At operation the tip of the catheter was found in a perivesicle pocket, having passed out through the laceration in the prostatic urethra. About five days after injury with inlying catheter and suprapubic drain both in place, extensive extravasation took place over night so that it was necessary to incise both thighs widely in the region of Scarpa's triangle. Following incision and drainage the patient made an uninterrupted recovery. The suprapubic drain was removed in three weeks. A week later the suprapubic sinus was healed solid and the inlying catheter was removed.

lished. Suprapubic cystotomy should be done as soon as the patient's condition permits. Following the skin incision it is often noted that the subcutaneous fat and muscle are infiltrated with blood due to the trauma, and on separating the muscles the perivesicle space will be found to contain varying amounts of blood and urine. Land marks are often obliterated. If after opening the bladder, Davis interlocking sounds do not work or are not available, a pair of ordinary sounds, (e.g., No. 24 and 25 F) may be tried. If these fail a catheter on a stilet may be tried. With a finger in the internal meatus the catheter may be guided into the prostatic urethra. (Fig. 7.) This, in the author's own experience, has been by



far the most successful procedure. If there is a wide separation of the distal and proximal ends of the severed urethra (Fig. 5), they may be drawn together by replacing the inlying catheter with a Hagner bag (Ormund and Cathran<sup>11</sup>), or as recently described by VerMooten,<sup>10</sup> using a Foley catheter. There may be sufficient shifting of the bony fragments of the pelvis to interfere with an inlying catheter and cause an acute angulation of the urethra after removal of the catheter. In this case the projecting bone fragments must be removed. Repair may be done through the perineum (Young<sup>12</sup>). Adequate drainage should be provided and this may be carried out through counter openings in the perineum. The inlying catheter should remain *in situ* fifteen to twenty days. Sounds should be passed at increasingly longer intervals until the patient can go three to six months without contraction of the stricture. They should be sounded at regular intervals for years afterward, if not for the remainder of their lives.

A high percentage of these patients are impotent following the injuries, whether due to damage to the blood or damage to the nerve supply to the penis is not established. This is of great importance from a medicolegal standpoint in regard to traumatic neurosis and neuropsychiatric disturbances.

Considerable stress has been placed on the necessity for prolonged follow-up procedures of these patients. Traumatic strictures contract much more rapidly than inflammatory (gonorrheal) strictures.

*Rupture of the Bladder.* This is relatively an uncommon injury, due largely to the fact that the bladder is placed deeply in the pelvis where it is inaccessible to trauma except in the most severe crushing injuries or fracture of the pelvis with penetration by a fragment of bone. The author has seen three or four patients from the field of industry. The writer reported on twelve patients from the Receiving Hospital of Detroit (Rexford<sup>13</sup>). In the series referred to, mortality occurred in

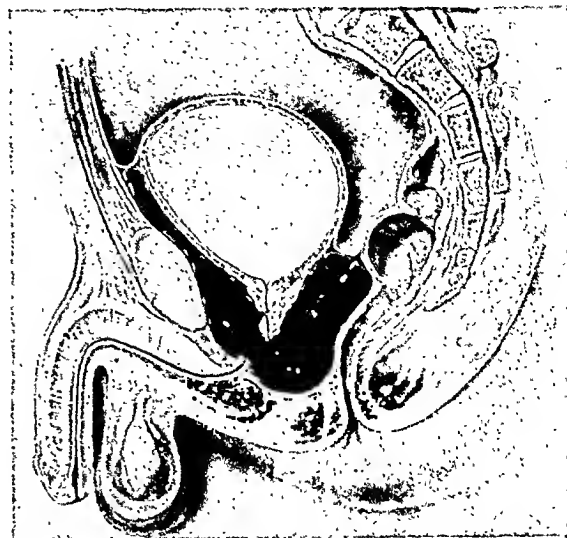


FIG. 5. Schematic representation of extreme degree of extravasation following rupture of urethra posterior to triangular ligament. This illustration shows why an inlying catheter may drain urine but still not drain the bladder and demonstrates the necessity of suprapubic cystostomy. It also shows the necessity of perineal drainage. This same type of extravasation may occur in extraperitoneal ruptures of the bladder. VerMooten<sup>10</sup> maintains that the separation and the floating up into the abdomen of the bladder and prostate leaves a palpable doughy area. This is palpable by rectum.

patients who had complications of multiple fractures, long bones and the skull. In a four-year period ending July 1, 1940, there were twelve patients in 83,500 hospital admissions. Dr. I. K. Bacon<sup>14</sup> reported on 147 ruptured bladders over a ten-year period with 488,000 admissions at the Los Angeles City General Hospital, which was about three times the incidence of occurrence in the above mentioned series.

These injuries were incurred in falls, automobile accidents and brawls, the majority having been more or less intoxicated. The conclusion is that it is almost impossible to rupture an empty bladder but that a full bladder may rupture fairly easily.

There is retention or slight dribbling of bloody urine, shock, rigid abdomen or pain and tenderness just above the symphysis. Catheterization may show a small amount of bloody urine or none at all, the urine draining back into the peritoneum. Cystoscopy is uncertain owing to the inability to distend a leaking bladder. In the author's



experience the cystogram makes the diagnosis, (Figs. 8 and 9) using either 15 per cent sodium iodide or a one-quarter strength skiodan solution as a contrast medium.

Treatment is immediate operation or as

The repair may be done transvesically or through the abdomen, the latter being safer as it provides an opportunity to inspect the abdominal contents for injury. It is probably safer to drain the bladder suprapubically, although if the injury is recent

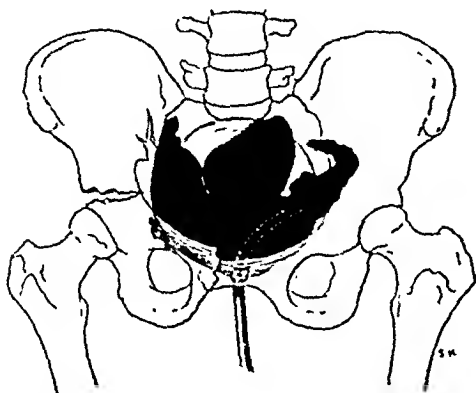


FIG. 6. Showing the anteroposterior view of Figure 5 and the catheter passing through the laceration in the urethra.

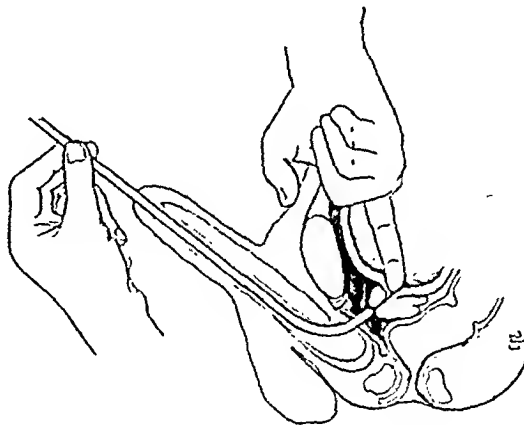


FIG. 7. Laceration of the urethra at apex of prostate; suprapubic cystostomy. The catheter on a flexible stilet is guided into the prostatic urethra by the operator's finger in the internal meatus.

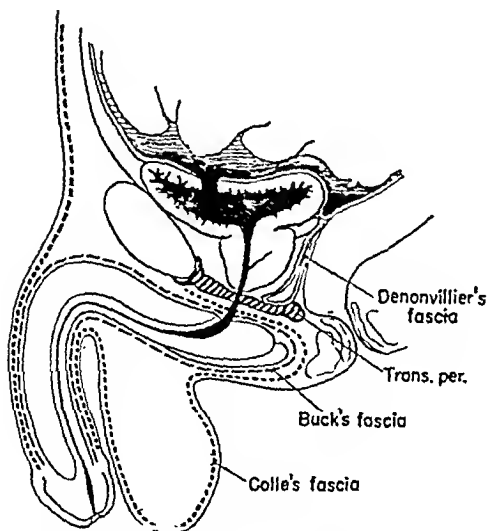


FIG. 8. Intraperitoneal laceration of the bladder with extravasation of urine into the peritoneal cavity shows futility of trying to find the opening with a cystoscope. The bladder collapses about the beak of the scope.

soon as the patient's condition permits. Delay is dangerous leading to peritonitis or perivesicle suppuration depending on the location of the tear—intra- or extraperitoneal.

a primary closure with a catheter drainage may be considered. If the rupture is extraperitoneal and of much duration, the perivesicle space should be well drained. Penicillin and the sulfonamides should be used freely. If primary closure is done, ten to fifteen days of catheter drainage should be ample to allow solid healing. If drained suprapubically, the suprapubic tube may be removed after five to six days and an inlying urethral catheter substituted until the suprapubic wound is dry. The necessity for immediate surgery cannot be emphasized too strongly.

In those patients with uncomplicated cases operate early and the mortality should be slight. The mortality varies inversely with the interval between injury and surgery.

**Kidney.** In spite of the fact that the kidney is tucked away in a rather inaccessible position, protected by the ribs, spine and abdominal muscles and cushioned in its fatty capsule which acts as a sort of shock absorber, injuries to it have not been uncommon; e.g., in a four-year period ending

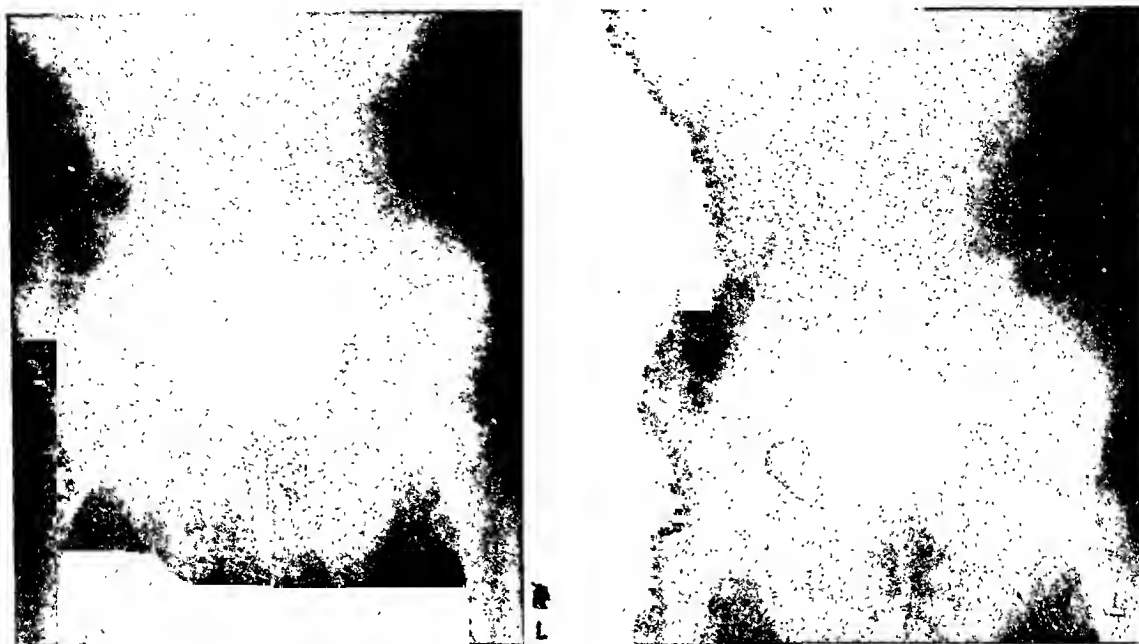


FIG. 9. Cystogram in laceration of the bladder showing contrast medium in abdomen; suprapubic cystotomy. The tear is 2 cm. back of the peritoneal reflection off the bladder. The peritoneum is pushed back and closed without drainage. The bladder closed about a suprapubic drain and the laceration closed as an extraperitoneal laceration. Note extravasation of urine into peritoneal cavity. Cystoscopy was without value as the bladder collapsed about the beak of scope.

July 1, 1940, at the City of Detroit Receiving Hospital on the urology services of Drs. Keane, Plaggemeyer and the writer,<sup>13</sup> there were 126 patients who were classified as having trauma to the genitourinary tract. Of these, fifty-eight were kidney injuries. The degree of injury varied from slight contusion with pinkish urine to gross hematuria with a complete shattering of the kidney or damage to the blood supply in a crushing injury with complete infarction of the kidney (Rexford<sup>15</sup>). (Fig. 13.)

Of the fifty-eight patients, forty-seven were not operated upon but were treated conservatively and they recovered; seven were operated upon with one death; three were released to other hospitals and one was not operated upon but died of shock.

All patients with cases of trauma should have an immediate urinary examination. If unable to void they should be catheterized. If there is bleeding there is very likely to be a kidney injury or a slight laceration of the bladder mucosa present. Most of these patients are treated expectantly with rest in bed, the hematuria subsiding. If this does not occur the patient should be



FIG. 10. Kidney trauma following a fall. A tear occurred into the cortex but not through the fibrous capsule. Contrast medium does not pass into the perirenal tissues. Rest in bed was followed by recovery.

cystoscoped and a retrograde pyelogram made. This will show the extent of the damage and determine whether bed rest



FIG. 11. Retrograde pyelogram showing contrast medium extravasating into perirenal tissues. The patient fell a few feet and a companion fell on top of him. He came into the hospital in shock, with grossly bloody urine, pain and rigidity in the upper left quadrant. On the following day an intravenous pyelogram showed no dye in the left side; on the next day a retrograde pyelogram showed the lower and middle calices filling, the dye passing out into the perirenal tissue. The patient's temperature had gone up and he did not present a good appearance. Immediate nephrectomy was done and the patient's condition improved and he looked fine. In this case, the upper third of the kidney was completely broken off and repair of the remaining portion was not feasible because of the damage to the blood supply. Recovery followed operation.

or surgery is indicated. (Figs. 10, 11 and 12.)

Intravenous pyelography has not been too satisfactory. A contused kidney often has its function temporarily delayed. The amount of abdominal distention occurring in these obscures the pyelogram if obtained and does not begin to give the information that cystoscopy and retrograde pyelography does.

The kidney has great recuperative powers as witnessed by the fact that it may be split from pole to pole for the removal of a calculus or the mauling it receives from the prolonged search for an elusive stone,



FIG. 12. Illustration of kidney showing impossibility of repair. An explosion threw the patient against a 2 by 4 railing, striking him in the left loin. He was brought into the hospital in shock. His blood pressure was 60/40. A blood transfusion was given the following day. The blood pressure rose to 120/70, but there was gross hematuria and marked ileus. An intravenous pyelogram showed the right kidney only. Hematuria persisted and on the following day the kidney was removed. It was completely broken in two. There was a large tear through the larger portion of the kidney and a large perirenal hematoma. Recovery followed removal.

either through a nephrotomy or a pyelotomy incision. In a few weeks these kidneys show a normal function and pyelogram.

In industry the chief causes of kidney injuries have been falls and blows to the abdomen. Usually there is little or no external evidence of injury.

It has been the writer's experience that the larger proportion of the patients with kidney injuries get well when treated conservatively and that about one out of six require surgery. The surgery in this case

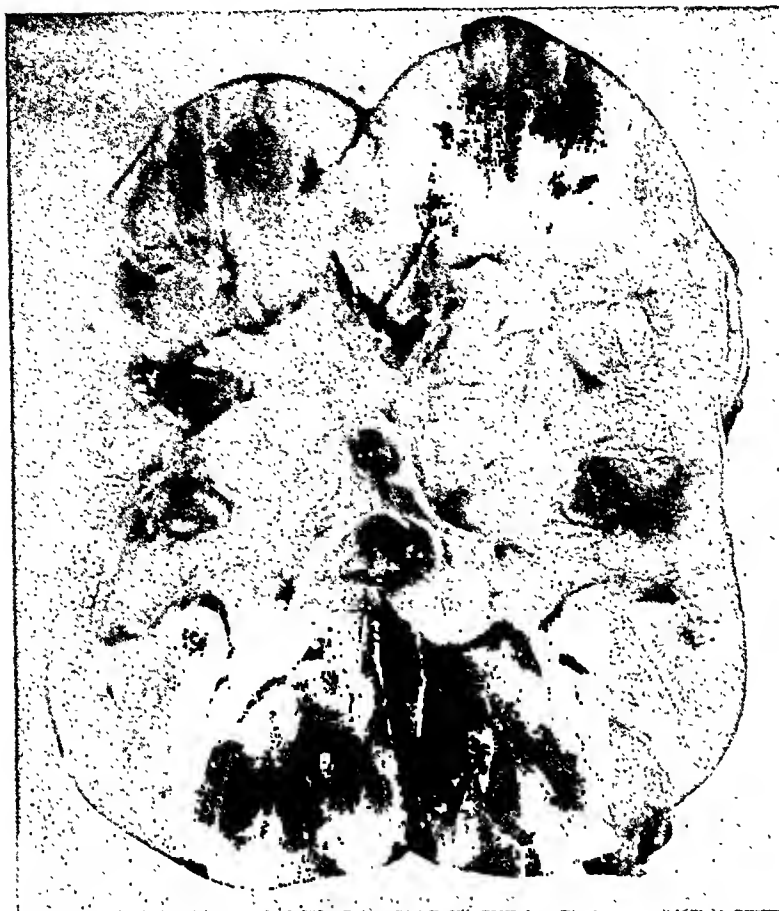


FIG. 13. Infarction of kidney in crushing injury. The man was crushed between a pillar and a moving crane. There was shock but no hematuria. A retrograde pyelogram was normal. There was no function or urine excretion at the end of 45 minutes. Nephrectomy. Huge infarcts of the kidney. Recovery prolonged because of damage to the tail of the pancreas and drainage of pancreatic fluid.

is nephrectomy. The author has never seen a kidney at operation that was amenable to repair; all were so badly broken or shattered that the only recourse was removal. The "does" and "don'ts" for traumatic kidneys are: Do not hastily rush into surgery; do not place much reliance on intravenous pyelograms and do have a cystoscopic examination and retrograde pyelogram made as soon as the patient's condition permits.

The management of traumatic kidneys have some time been described as "masterly neglect."

#### CONCLUSIONS

All injured patients who do not void a clear urine in a comparatively short time should be catheterized on the off chance that there may be some damage to the

urinary tract. In other words, a urinary examination must be done on all patients.

All injuries involving the urinary tract should be investigated with a catheter: (1) If the catheter is obstructed, there is damage to the urethra at the point of obstruction. An urethrogram will show the amount of extravasation; (2) If the catheter passes, inject contrast medium and have x-rays made. This may show: (a) A passage of the contrast medium into the peritoneum if an intraperitoneal rupture is present (Figs. 8 and 9); (b) passage of the contrast medium into the perivesicle region. This may be due to either an extraperitoneal rupture of the bladder or a tear through the prostate or urethra, posterior to the triangular ligament and (c) a normal cystogram with bloody urine.

If conditions (1) or (2a) or (2b) are

present immediate surgery is indicated. Delay means extravasation of urine and infection, necessitating multiple incisions and prolonged convalescence. If condition (2c) is found there may be a slight laceration of the bladder mucosa or varying degrees of kidney damage. Here, one may delay. An intravenous urographic study and cystoscopy with retrograde pyelograms should be carried out as soon as the patient's condition warrants. The majority of these patients get well with rest in bed.

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# DIAGNOSIS AND MANAGEMENT OF PERIPHERAL NERVE INJURY\*

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**D**YSFUNCTION of a peripheral nerve may occur from contusion and laceration in wounds, in association with fracture and dislocation of long bones and in some instances by chronic irritation. By far the most common type of interruption is that due to involvement in lacerations, bullet and other penetrating wounds. This paper will deal primarily with the diagnosis and management of nerve injury in lacerations. A few comments will also be made concerning involvement in dislocation and fracture of long bones and from chronic irritation.

## NERVE INJURY IN LACERATIONS, BULLET AND OTHER PENETRATING WOUNDS

In civilian practice the most common site of involvement is at the wrist and the forearm. Fully 60 per cent of the patients we have had in our group belong in this category. The incidence in penetrat-

ing wounds of World War II shows that the upper extremity was involved in 70 per cent of the patients and the lower in 30 per cent.<sup>1</sup> The ulnar nerve was most commonly injured (32 per cent of the total). The median nerve accounted for 19.5 per cent; the radial 14.1 per cent; the sciatic 16.9 per cent and the peroneal 7.9 per cent; all others were less than 3.6 per cent (tibial etc.). In Table I the nerves involved in 174 civilian patients with nerve section are given.

## DIAGNOSIS

The diagnosis of a nerve interruption is usually simple. Mistakes are frequently caused by an oversight of the possibility of nerve involvement. In many instances a few questions and answers clinch the diagnosis. The location of the laceration should suggest to the examiner the possibility of nerve involvement. A laceration in the middle of the palm-wrist junction may be associated with section of the median nerve. A more medial laceration may involve the ulnar nerve. An extensive laceration of the wrist often involves both ulnar and median nerves. A relatively superficial laceration over the epicondylar groove on the medial aspect of the arm may involve the ulnar. The radial nerve may be sectioned by a laceration on the anterolateral aspect and below the middle third of the arm. A laceration on the lateral aspect of the head of the fibula can result in section of the peroneal nerve. The location of the laceration alone should, therefore, suggest possible nerve involvement.

The cardinal neurologic features of either anatomic or physiologic nerve interruption

TABLE I

Face	
Facial nerve.....	7
Upper Limb	
Wrist	
Median.....	42
Ulnar.....	30
Median and ulnar.....	16
Forearm	
Median.....	4
Ulnar.....	13
Radial.....	6
Mixed.....	5
Arm	
Median.....	6
Ulnar.....	8
Radial.....	14
Mixed.....	10
Axilla	
Brachial plexus.....	8
Lower Limb	
Femoral.....	1
Sciatic.....	4
Peroneal.....	7

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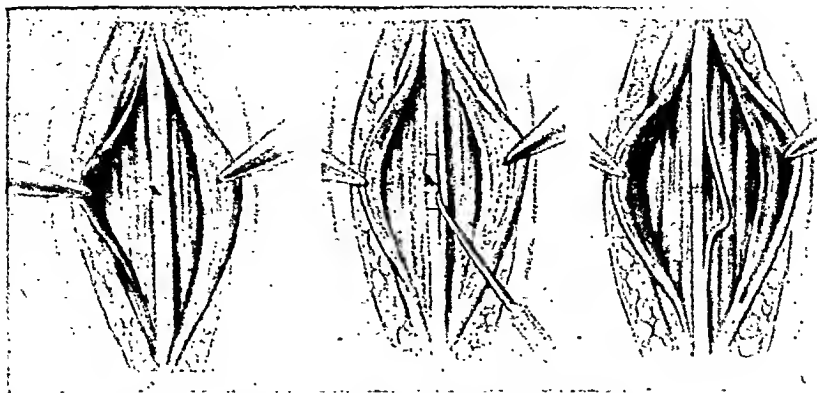


FIG. 1. Partial section of a nerve and operative management. The uneut portion is carefully separated from the cut portion. The ends of the cut portion are sutured after débridement.

include sensory changes, motor loss and sudomotor paralysis. In some nerves the sensory defect is most prominent while in others it is the motor and in still others, both motor and sensory involvement are quite marked. There is usually sudomotor paralysis in the area of anesthesia in extremity nerve section. A more refined, objective and practical method of evaluating zones of nerve interruptions is by means of measuring the changes in electrical skin resistance.<sup>2</sup> In the denervated skin area there is an absence or decrease in sweating with consequent increase of the electrical resistance. By means of the dermometer an involved area can be accurately plotted. This method does not depend upon the subjective responses of the patient.<sup>3</sup>

A few simple points suffice to diagnose accurately a given nerve lesion. In the next few paragraphs these will be described.

#### *Diagnosis of Nerve Lesions:*

*Median nerve* section may be identified by the presence of sensory loss in the lateral three and one-half fingers and the corresponding portion of the palm. These patients also have anesthesia of the distal two phalanges of the index, long and one-half of the ring finger on the dorsal surface. Such a sensory pattern often clinches the diagnosis of median nerve dysfunction. There is a motor defect characterized by inability to flex the distal phalanx of the thumb and index fingers. Opponens pollicis impairment and subsequent atrophy occur.

*Ulnar nerve* interruption results in a sensory loss characterized by involvement of the little finger, one-half of the ring finger and the corresponding portion of the palm and the dorsum of the hand, if the section is high enough to be above the dorsal cutaneous branch. There are marked motor phenomena in ulnar nerve involvement, with impairment of finger adduction and abduction, thumb adduction and inability to flex the proximal or distal phalanges of the ring and little fingers. An accurate diagnosis can be based upon a sensory loss in the majority of patients.

*Radial Nerve.* The important feature of radial nerve interruption is wrist, finger and thumb drop with little or no sensory loss. Interruption of the posterior interosseous branch in the forearm impairs only digital extension. The possibility of extensor paralysis from the section of tendons in the forearm should also be entertained.

*Musculocutaneous Nerve.* The diagnosis of injury to this nerve is based upon the presence of paralysis of the biceps muscle. There is loss of sensation on the anterolateral surface of the forearm (lateral antibrachial cutaneous nerve) with impaired flexion and supination of the forearm and loss of the biceps reflex.

*Axillary Nerve.* A paralysis of the deltoid muscle is diagnostic of axillary nerve dysfunction. This results in weakness of abduction of the arm to the horizontal plane and a sensory defect over the deltoid muscle.



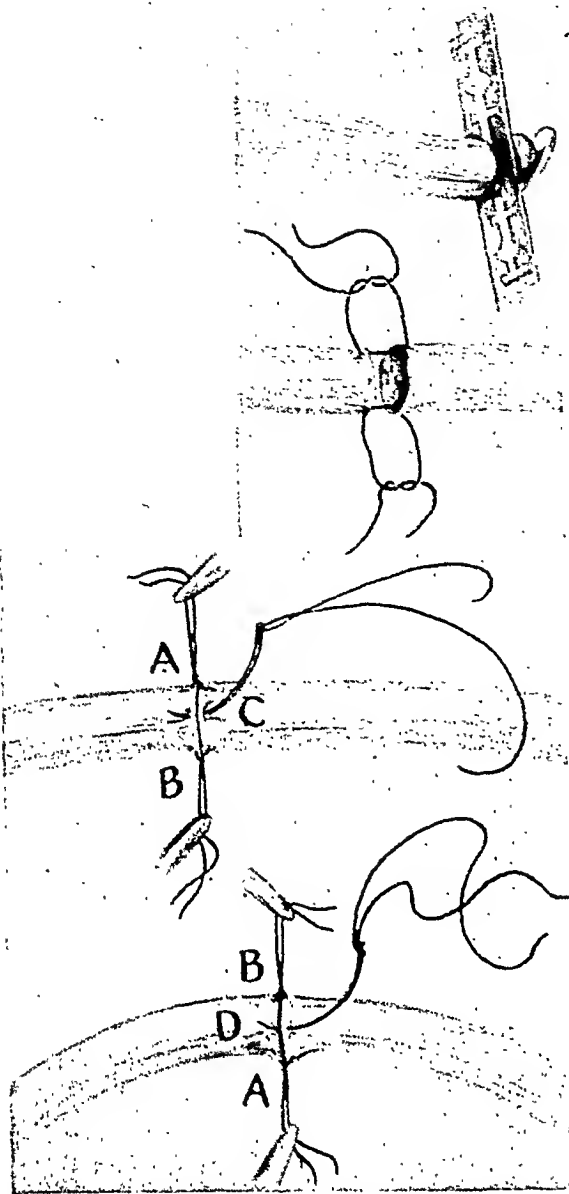


FIG. 2. The technic of nerve suture in fresh wounds. The nerve ends are débrided with a razor blade. Sutures are passed at A and B; an interrupted suture is used at C. Then the nerve is turned over and another interrupted suture is placed at D. It is important to keep the nerve ends in their anatomic position.

**Brachial Plexus Involvement.** A laceration of the supraclavicular region of the neck with varying degrees of paralysis of the upper limb denotes brachial plexus dysfunction. The upper plexus involvement results in a disturbance in the function of the axillary, musculocutaneous and median (partial) distribution. A lower brachial plexus involvement is manifested in median, ulnar and radial paralysis.

**Multiple Nerve Involvement in the Upper Extremity.** In many instances more than

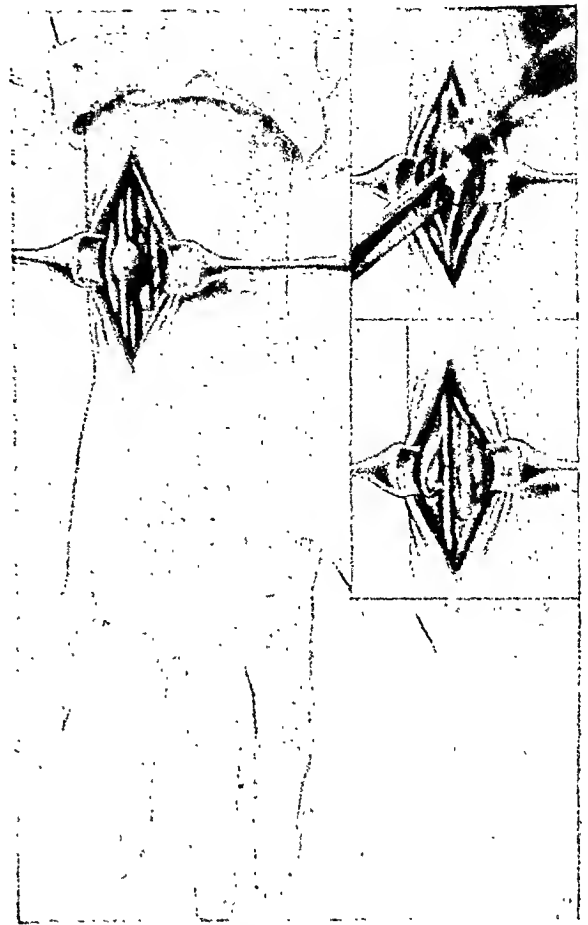


FIG. 3. Neuromatous degeneration of the ulnar nerve from partial section. The neuromatous portion is carefully dissected free from the non-neuromatous portion. The neuroma is excised and the ends of the nerve are sutured.

one nerve is involved, e.g., median and ulnar in wrist lacerations. This type of section may be complete or incomplete, giving varying patterns of sensory loss some of which are confusing.

In the lower extremity the sciatic and its two terminal branches, the peroneal and tibial, are infrequently injured in civilian lacerations. The femoral is even less commonly involved. The leading and gross diagnostic features of interruption of these nerves may be summarized as follows: *Sciatic nerve:* Paralysis of flexion and extension of the foot and toes accompanied by a large area of anesthesia involving the foot and leg may be readily observed. The hamstring muscles may be involved in high interruption. *Tibial nerve;* There is paralysis of flexion of the foot and the toes with sensory loss over the sole of the foot. Foot inversion is also impaired. *Peroneal nerve;*

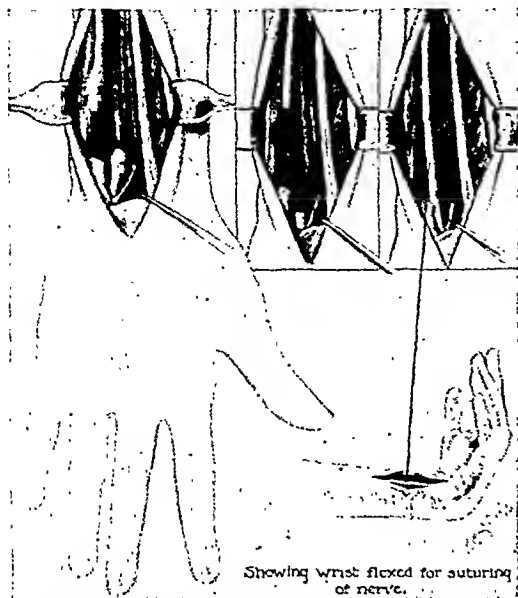


FIG. 4. Old ulnar nerve section. The neuromatous portions of the proximal and distal ends are excised with a razor blade and the nerve is sutured with interrupted silk. The wrist is flexed to obtain suture without tension.

A characteristic paralysis of extension and inversion of the foot and toes with sensory loss along the dorsum of the foot and the lateral aspect of the leg is present. *Femoral nerve:* There is paralysis of the quadriceps femoris with a sensory defect along the anterior and medial aspect of the thigh and leg. Extension of the leg is lost as is the patellar reflex. The thigh cannot be flexed on the abdomen.

*Sacral and lumbar plexus* involvement is uncommon in civilian practice. Such injury results in complete or partial paralysis in the distribution of the sciatic and the femoral nerves.

The associated occurrence of injury to tendinous and muscular structures should be considered and the extent of the non-neural involvement carefully ascertained prior to nerve exploration. A preoperative evaluation of the extent of both nerve and tendon involvement is important. The wound should never be entered before such a clinical assessment of the extent of damage has been made and recorded. Tendons, after section, may retract out of view and they may be difficult to secure unless searched for. We have seen exam-

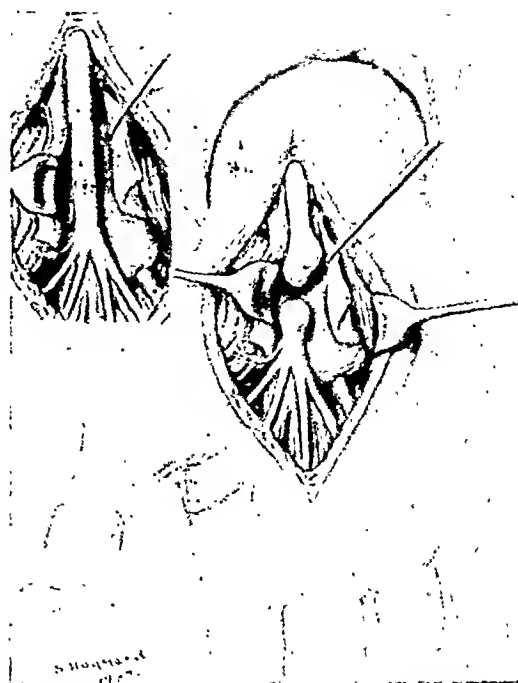


FIG. 5. "Faucet injury" of the interthenar region at the wrist-palm junction, with section of the median nerve.

ples of the distal ends of nerves sutured inappropriately to the proximal ends of the wrong nerves or tendons in patients with multiple nerve and tendon injuries.

#### OPERATIVE TREATMENT

Before the era of penicillin and sulfa therapy, the attempt was made to suture lacerated nerves before twelve hours had elapsed. In instances when suturing was not within twelve hours the wound was closed and neurorrhaphy then was accomplished six weeks after the wound had healed. The patient with a wound infection waited three months after wound healing before nerve suture was attempted. With biologic agents and chemotherapy nerves can be sutured as late as thirty-six hours after the accident. In instances where the wound had been closed the nerve repair may be done after swelling, redness and edema of the wound have subsided.

The present day plan is to suture nerves as soon as possible. Infected wounds should be permitted to heal and after healing has taken place nerve repair may be carried out in four weeks. In bullet wounds we have



FIG. 6.

FIG. 7.

Figs. 6 and 7. The same case as in Figure 5. Note the scar of the "faucet injury" at the palm-wrist junction.

learned from the experiences in World War II that it is better to wait from six to eight weeks before suturing is attempted. Whereas a few hours after injury a nerve may appear only slightly contused, six weeks afterward the true state of that nerve becomes apparent.

The operative management in primary suture consists of débridement, extension of the incision to give adequate exposure and the suture of tendinous structures as well as the sectioned nerve. If the nerve is partially sectioned, a neurolysis is performed separating the cut from the uncut portion. (Fig. 1.) The cut portion is then sutured. In complete nerve section, end-to-end suture is effected after excising the nerve ends with a razor blade. (Fig. 2.) If there is a significant gap to overcome, the nerve must be extensively dissected and freed. Transposition may be of assistance. The limb may be fixed in a desired position so as to permit end-to-end suture without tension. Three weeks are allowed for resumption to a normal position of the extremity. Nerve stretching should be avoided when possible.

In secondary suture, usually there is neuromatous degeneration at the proximal

end and some bulbous enlargement of the distal end of the nerve. At times the neuromatous involvement may be due to a partial section. If so, the normal nerve bundles should be separated from the cut nerve and after excision of the neuroma the nerve ends sutured. (Fig. 3.) When the bulbous neuromas of the proximal and distal end are at a distance from each other, after excision of each neuroma, the nerve ends are sutured. (Fig. 4.) In our work we use silk No. 0000 for nerve suture as well as for the repair of sectioned tendons. During World War II the use of tantalum suture material and tantalum foil has become popular. As suture material it has been held that tantalum produces less tissue reaction than silk; it is more secure in the event of infection and it permits a visualization of suture line separation by means of roentgen studies.<sup>4</sup> The use of tantalum foil to surround a suture line has been employed mainly to prevent scarring in this vulnerable and strategic point. It has also been suggested that a tantalum sleeve acts to direct the peripheral growth of the interrupted axones. Certain disadvantages have been recognized as concern the use of the tantalum sleeve; it may jeopardize the

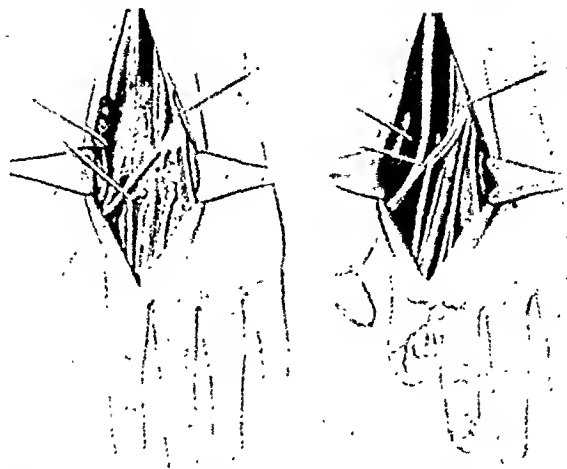


FIG. 8. "Faucet injury" of the interthenar region at the palm-wrist junction with section of median nerve branches and the flexor tendons of the thumb and index finger.



FIG. 9.

FIG. 10.

Figs. 9 and 10. The same case as in Figure 8 one year later with good return of function.

blood supply of the nerve and there may be fibrosis at the junction of the end of the sleeve and the intact nerve.<sup>5</sup> Therefore, the use of a tantalum nerve wrapping appears to be undesirable. There is little or no objection to the suture material.

Of particular interest are those patients having "faucet injury" wounds with laceration of the interthenar region at the palm-wrist junction. Although such wounds

look benign, there may be varying degrees of involvement of major structures. In our experience complete or partial section of the median nerve, or in more distal injuries, of one or more branches has occurred. (Figs. 5, 6 and 7.) Occasionally, the flexor pollicis longus tendon and/or the flexors of the index finger were lacerated. (Figs. 8, 9 and 10.) With such extensive involvement it is apparent that early diag-



FIG. 11.

FIG. 12.

FIGS. 11 and 12. Tardy ulnar neuritis due to valgus deformity of right elbow. Note the atrophy of the adductor pollicis and interossei. This patient also had hypesthesia in the ulnar distribution of the hand and some flexion deformity of the little and ring fingers of the right hand.

nosis and operative repair is essential. The individual branches of the median nerve in the palm are quite large and easily sutured.

Some authors suggest the suture of digital nerves in laceration of fingers.<sup>6</sup> This is particularly easy in fresh wounds and should be practiced.

The prime purpose in the surgical management is the establishment of an ideal environment for regeneration. There are many known and unknown quantities which influence this process. There are some factors which the surgeon is able to control. In brief, he must provide a proximal stump which contains axones physically capable of regeneration (excision of neuromatous end) and the distal stump must be receptive to axonal growth (excision of bulbous end). The point of anastomosis requires every effort to eliminate scar provoking influences. Internal stump scarring can result in interruption of axonal growth and complete failure. External stump scarring can result in a delayed arrest of function which is equally unsatisfactory. Therefore, stump trauma and excessive manipulation should be avoided. The most reactionless type of suture material should be used. Hemorrhage should be prevented by proper stump apposition without tension. It is important to keep the nerve stumps in their anatomic position in order to match the fascicular topography. Early nerve suture is of physiologic

necessity since as time proceeds there is a gradual but progressive distal segment fibrosis and atrophy. This, with the associated muscle atrophy of the part supplied and the articular fibrosis and trophic disturbances, leads to irreversible conditions preventing rehabilitation of the part.

#### NERVE INJURY IN ASSOCIATION WITH FRACTURES AND DISLOCATIONS

Nerve injury in association with fracture and dislocation may be primary or secondary. The diagnosis of a primary nerve injury is often overlooked. The complication is discovered several weeks after removal of a cast or splint.

In our group of patients the radial nerve involvement was the most common and was associated with fractures of the humerus. The type of nerve involvement is given in Table II.

TABLE II  
CASES OF NERVE INJURY IN ASSOCIATION WITH FRACTURE AND DISLOCATIONS<sup>7</sup>

Radial.....	32
Ulnar.....	9
Median.....	3
Peroneal.....	8
Sciatic.....	1
Total.....	53

Of particular interest are the patients with peroneal nerve involvement in adduction injuries of the knee. The likelihood of nerve laceration is great, if there is a fracture of the proximal end of the fibula. The



FIG. 13. Tardy ulnar neuritis of the right hand in a patient with no evidence of valgus deformity of the right elbow. Scarring at the epicondylar groove of an old injury caused the irritation.

skin overlying the knee may be intact. Early exploration of primary peroneal paralysis is desirable in injuries of the knee joint with fractures of the upper end of the fibula. In general, it may be stated that a nerve should be explored if there is no evidence of regeneration three to four months after the fracture of a neighboring bone. In compound fractures associated with nerve lesion, earlier repair is feasible with biologic agents and chemotherapy as adjuncts in management. In fractures of the middle third of the humerus, complicated with radial paralysis, exploration in eight to ten weeks is justifiable if there is no evidence of returning function.

In dislocations of the shoulder joint, the axillary nerve and the lower portions of the brachial plexus may be involved. There is no evidence that operative treatment of this complication is any more successful than conservative management. Fractures and dislocations about the elbow may be



FIG. 14. Transposition of the ulnar nerve to the anterior aspect of the elbow joint in cases of tardy ulnar neuritis. Neurolysis may or may not be necessary.

associated with nerve injury and in one of our patients the median nerve was found within the elbow joint after reduction of a dislocation. It has been pointed out that acute palmar flexion of the wrist in the treatment of Colles fracture may result in median nerve involvement. It is also stated that dislocation of the carpal-lunate anteriorly may produce median interruption at the wrist. In dislocation of the hip joint there is rare involvement of the sciatic nerve.

#### LATE OR TARDY NEURITIS (USUALLY ULNAR)

Tardy ulnar neuritis, described by Panas,<sup>8</sup> is commonly encountered. A few instances of late median neuritis have been described. We have seen an example of late neuritis of the sciatic nerve due to gunshot wound eleven years after injury.

Tardy neuritis of the ulnar nerve may be produced in the following two manners. First, injury in childhood to the lateral condyle with improper union results in valgus deformity of the elbow. (Figs. 11 and 12.) Several years later, increasing bony and soft tissue tension upon the ulnar

nerve results in its dysfunction with both sensory and motor phenomena. Paresis and atrophy are common. Second, tardy ulnar neuritis may also result from arthritic and minor injuries in the medial epicondylar neighborhood, with adhesions between the nerve and surrounding tissues resulting in chronic irritation with eventual ulnar dysfunction. (Fig. 13.) The treatment of this condition by transposing the ulnar nerve to the anterior aspect of the elbow and neurolysis when indicated is well standardized and accepted. (Fig. 14.)

#### REHABILITATION

Splints of affected parts are, in general, of little help in rehabilitation. The advantage of preventing overstretch of muscles is offset by the disadvantages of immobilization, resulting in inactivity of the affected muscles. The patient looks upon the splint as a form of treatment and overlooks the insidious fixation of the joints and muscle atrophy; however, patients with dropped wrist, shoulder or foot should have the parts neutralized, especially during sleep.

The plan of rehabilitation for the patient with peripheral nerve injury must begin immediately after trauma. As early as possible the patient must be instructed and repeatedly advised regarding the importance of continuous physiotherapeutic exercise of the affected part. Instead of maintaining a passive rôle, an active, interested and cooperative viewpoint must be indoctrinated in the patient.

Any surgical procedure is but a single step in the treatment. A successful result also depends on continuing exercise per-

formed through a period of months. The patient cannot simply be told to exercise his extremity. He should be taught the gross fundamentals of the anatomy and physiology of the involved part and the rôle of occupational physiotherapy. This can best be done by a therapist who with adequate facilities can teach and encourage progress. The facilities are simple devices which stimulate the patient to exercise and illustrate muscle movements which he in turn can imitate. It is of importance that the patient participates in the experiences and progress of those also employing the physiotherapy and occupational facilities. He can be impressed by seeing the retarded patient who neglected his hand or he can be stimulated by the progress of the cooperative patient.

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# EMERGENCY EYE CARE IN GENERAL PRACTICE\*

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OCULAR injuries constitute but a very small part of the multitude of conditions those in the general practice of medicine are called upon to treat. Because of their relative infrequency, however, the physician is often at a loss as to the proper approach in their management. This feeling of hesitancy is heightened by the realization that improper care may cost the patient his eyesight. It is not always possible nor always necessary to refer these patients to those especially interested in eye care since most ocular emergencies can and should be cared for by those who first see the patient. Delay caused by sending the patient some distance to a specialist may in itself result in a poor outcome. With such a thought in mind let us review some of the more common emergency ocular conditions and make some suggestions that may help in obtaining a good result.

Probably the most common eye condition seen in general practice is the corneal foreign body. In removing the foreign substance it is necessary to have adequate anesthesia, good illumination and good magnification. Without these aids the operator is more than likely to scrape off a large area of corneal epithelium and thus add to the severity of the patient's injury. Adequate anesthesia is best obtained by drugs such as  $\frac{1}{2}$  per cent pontocaine which does not soften the corneal epithelium and thus promote epithelial stripping such as is obtained with cocaine. A Beebe binocular loupe and small pencil flashlight together with an assortment of sterile foreign body spuds complete the equipment. If foreign body spuds are not at hand a small sterile hypodermic needle on a small Luer syringe will suffice. Many

foreign bodies can be removed by simply brushing them off the cornea with a wet cotton applicator. It is necessary to remember that the charred tissue about the actual foreign body must be completely removed if the lesion is to heal. It is my practice to instill butyn-metaphen ointment and pad these eyes for a few hours following foreign body removal. If there is ciliary injection and the area of trauma in the cornea is hazy, uveitis and ulceration are probably present and the patient might better be turned over to your ophthalmologist. Foreign bodies imbedded in an area 6 mm. in diameter in the center of the cornea must be handled with great respect since this area is the optical zone of the cornea. Even faint scars of this zone will result in considerable permanent visual loss.

Corneal abrasions undoubtedly are next in order of frequency. These are often missed by the examiner if the abrasion is not stained with 2 per cent aqueous fluoresceine. Abrasions usually heal readily in a day or two by instilling some combination ointment such as butyn-metaphen or metacaine-merthiolate and tightly padding the eye.

Blunt, non-perforating, contusive injuries to the eyeball are rather frequent among children. Fortunately the protection afforded by the bony orbital rim prevents most of these injuries from doing serious harm. The plebian black eye is best treated, if seen immediately, by applying continuous ice compresses. This will largely control the edema. Hot wet compresses may be preferred if the process is seen later when edema is present. The heat will merely hasten the absorption of blood. If it is necessary for the injured individual to make a public appearance, the dis-

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coloration of the lids may be masked by the use of the cosmetic labeled "Cover Mark" which may be secured from any beauty parlor.

Contusive injuries to and about the eye should not be passed over lightly, however, until the orbital rim and interior of the eye have been thoroughly searched for more serious damage. Fractures of the orbital rim showing considerable depression may result in displacement of the eyeball and disturbances in its motility. Such displaced fractures should be replaced at once or as soon as the edema has subsided.

A subluxated lens, resulting from contusion, will not respond to treatment but by discovering its presence, embarrassment to the examiner may later be avoided. The same is true as regards vitreous hemorrhage or ruptures of the choroid. When the latter conditions are found the eye should be watched for development of retinal detachment. Should detachment of the retina occur, immediate ophthalmological care is imperative.

Blunt injuries to the globe not infrequently are followed immediately or later by massive anterior chamber hemorrhage. This complication is one which requires careful observation and unless you are sure of your grounds you might better shift the responsibility to an ophthalmologist. Most anterior chamber hemorrhages will absorb fairly readily with the use of 1 per cent eserine or 2 per cent pilocarpine, four times a day, together with hot compresses. Others may persist or result in a secondary rise in intra-ocular pressure. Since this pressure, in the presence of anterior chamber hemorrhage, leads to the development of blood staining of the cornea, the increased pressure must be relieved immediately by corneal paracentesis. The use of eserine or pilocarpine will have no influence on the pressure and valuable time should not be lost in trial. I have yet to see an eye showing blood staining of the cornea which eventually obtained useful vision. I have not seen blood staining of the cornea result from anterior chamber hem-

orrhage when there was no increased ocular pressure. These two observations emphasize the necessity for early recognition and correction of the glaucoma in this type of ocular trauma.

The anterior chamber hemorrhage from

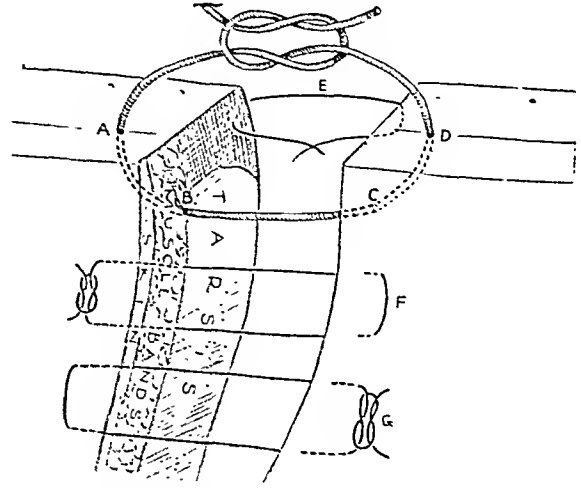


FIG. 1. Transmarginal laceration of lower eyelid. A, B, C and D, points of entrance and exit of suture uniting intermarginal groove; E, deep buried gut sutures uniting tarsal plate; F, sutures uniting obicularis muscle bundles, either buried or not; G, cuticular sutures.

blunt non-perforating contusion to the eyeball often results from lacerations of the iris. The weakest part of the iris is its attachment to the ciliary body. Laceration of the iris at this point results in a pulling away of the iris at its base. If this is severe, the pupil is usually strongly displaced towards the opposite side. Slight to moderate displacement of the pupil gives no visual impairment, but marked pupillary displacement gives marked loss of vision. These latter cases indicate the need of surgical correction.

Perforating injuries to the eyeball by flying particles point to the desirability of x-ray of the globe. X-ray of the eye should be done in all instances in which the history suggests the possibility of intraocular foreign body. Many of these eyes have an obvious perforation of the globe, but in others careful search reveals no point of entrance. An undiscovered intra-ocular metallic foreign body may give no symptoms for years. More commonly they result in recurrent iridocyclitis, endophthalmitis,

cataract or siderosis bulbi. Once the retained foreign body has rusted away and the rust disseminated through the eyeball, the globe becomes phthisical. Those physicians connected with industrial first aid stations or those not especially interested

There are many types of chemical burns involving the eyes and in general they are to be considered as serious. The alkalis are usually more damaging than the acids in that they have a tendency to keep on working deeper and deeper into the tissues while

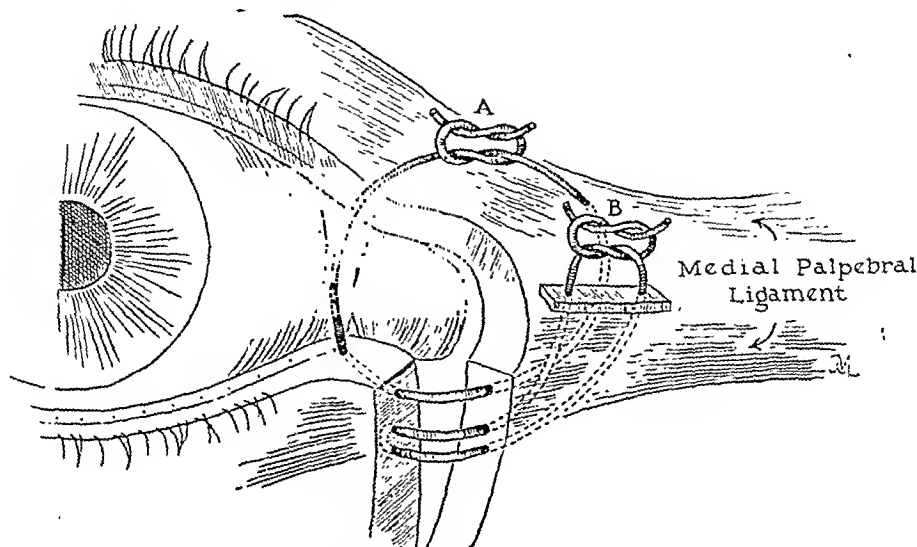


FIG. 2. Laceration of eyelid at inner canthus severing lower lacrimal canaliculus. A, heavy chronic gut suture threaded through the canaliculus and into the lacrimal sac, coming out through the skin at the upper pole of the sac; B, traction suture anchoring severed lid to the internal palpebral ligament. Deep conjunctival gut sutures, oblique muscle sutures and skin sutures inserted in layers to close remainder of lid defect.

in eye care should not burden themselves with the responsibility of caring for these patients. A fairly high percentage of enucleations eventually follow perforating ocular injuries.

With the advent of relatively inexpensive ultraviolet lamps, their use in the home is becoming more common. The users of these lamps sooner or later become careless and do not adequately protect the eyes while taking a sun bath. Since the eyes are sensitive to infra-red and ultra-violet rays nearest to the visible spectrum we occasionally see these people with violent edema, photophobia and pain. No permanent damage is produced by this severe reaction but adequate care is needed to give comfort. Ice compresses, dark room and the instillation of phenocaine-epinephrine ointment will give almost complete relief. Arc welders and electricians receive similar types of electric ophthalmia.

the acids coagulate the proteins of the surface cells and thus produce a more superficial lesion. Cicatricial contraction of the conjunctiva result in symblepharon of varying degrees.

The first treatment is the most important. Speed and thoroughness are the main requisites for a satisfactory end result. Chemical burns should be treated immediately by copious washing with tap water. The more water used the better. Care must be used to evert the eyelids no matter how serious the blepharospasm. Only too frequently the plaster, lime or other chemical is left in the retrotarsal folds to act over a long period of time. No attempt should be made to neutralize an acid with an alkali, etc. Adhesions should not be allowed to form between bulbar and palpebral conjunctiva. By passing a small, smooth, glass rod covered with vaseline between the lids and globe once

or twice daily symblepharon may be prevented.

Lacerations involving the margin of the eyelid require immediate and accurate repair if cosmetic defects and functional disturbances are to be avoided. Most of the textbooks on ophthalmic and plastic surgery deal with methods of correcting the late deformities which result from lacerations of the eyelids. More emphasis should be placed on methods of preventing deformities resulting from recent lid trauma. The physician who first cares for these patients has the best opportunity of giving a good cosmetic and functional lid. Lack of an appreciation of this fact often results in hasty and bungled repairs which later have to be reoperated with less chance of a satisfactory result.

Lacerations of the eyelids may be of relatively minor importance compared with the shock and other more serious trauma which the patient may have coincidentally. Rather than make hasty and inadequate repairs under these circumstances, the eyeball should be covered, if exposed, and the repair of the lid lacerations left until a time when more meticulous care can be expended on their suturing. The longer the interval between injury and repair, the more edema is present. This edema distorts the tissues of the lids and to some extent complicates the surgery. If ice compresses are kept on the lids until the surgery can be started, much of the edema can be prevented.

Extramarginal lacerations require more care than do lacerations elsewhere on the body surface. It is necessary to recall that there is very little tension on the tissues of the lids and therefore much finer sutures and needles should be used to give the least possible scar. Use No. 000000 black silk with atraumatic needles for all skin and conjunctival repairs of this type. No silk, gut sutures or knots should ever be allowed to come into contact with the cornea from the inner surface of the lid. For proper lid action it is imperative that extramarginal lacerations severing orbicularis muscle bun-

dles be reunited as a layer. This is best done with No. 00000 mild gut sutures on atraumatic needles. When the levator tendon is severed, it should be isolated and sutured with No. 00000 medium gut to prevent ptosis. It is far more difficult to make this correction in a healed deformity. If meticulous cleansing of the wound is carried out, no drainage tubes need be inserted. Only crushed tissues are excised.

Transmarginal lid lacerations, on the other hand, require even more meticulous repair if the results are to be both cosmetic and functional. Here again we must stress the need for using fine sutures and atraumatic needles and the least débridement possible. No. 000000 silk is used on the skin surface and No. 00000 or No. 000000 gut is used for the buried sutures.

The most important suture to be placed is that uniting the intermarginal groove. This is the grey line situated between the openings of the Meibomian glands and the eyelashes. If the first suture placed passes through this line down into the substance of the tarsus and then across the line of laceration to enter the tarsus at the same distance from the lid border and comes out in the intermarginal line on the other side of the laceration (Fig. 1), the lid border will be in perfect alignment. This enables us accurately to insert the deep buried gut sutures closing the tarsoconjunctival surface and the superficial silk sutures closing the orbicularis muscle and skin. Silk, gut sutures or knots should never be left in contact with the corneal surface since the movement of the globe will cause abrasion and scarring.

Minsky<sup>1</sup> has made helpful suggestions which aid in obtaining smooth union of the lacerated lid border. He splints the two lid borders together by passing the sutures uniting the lacerated lid margin through the opposite contacting lid border and then brings the sutures out through the skin above the lashes, tying them over a rubber plate. Where more than one laceration of the lid border is present, this splinting suture method of Minsky may be

utilized with advantage. Should the trans-marginal lid laceration involve both lids at the same point, Minsky's figure-of-eight suture may be used. This gives perfect alignment and splinting of both lid borders. The deep buried conjunctivotarsal gut sutures and the superficial musculo-cutaneous silk sutures are inserted as previously mentioned.

Special precautions are necessary when lid lacerations involve the external or internal canthus. Should the external canthal ligament be severed or evulsed, the lids are not held tightly against the globe and epiphora and ectropion will result. It is therefore necessary to see that strong No. 0000 gut sutures unite the severed ends of the ligament. Should there be tissue loss and the ligament not identified, the outer ends of the tarsal plates should be united by sutures with the periosteum behind the lateral orbital rim at the point conforming to the outer canthus. The orbicularis muscle fibers near the lid border should be included in the cutaneous sutures since these muscle fibers play an important rôle in keeping the lid border from turning out in ectropion. The inter-marginal sulcus is again utilized in lacerations at the outer canthus since a suture passed through this line below the canthal laceration and then across the laceration to come out in the intermarginal sulcus of the other lid will perfectly reform the canthal angle.

Lacerations and evulsions of the inner canthus involve even more important anatomical structures since only too commonly the lacrimal passages are severed. Unless the inner canthus is properly restored and the lacrimal passages remain patent, troublesome epiphora results.

When the laceration goes across the

lower canaliculus, a heavy chromic catgut suture is threaded through the punctum and canaliculus and through the medial cut end of the canaliculus and into the lacrimal sac. (Fig. 2.) The needle is brought out through the upper pole of the lacrimal sac and through the skin above the internal palpebral ligament and tied.

It is necessary to anchor the inner end of the severed lid to the internal palpebral ligament or periosteum. This is best done by passing a double armed No. 2 braided silk suture through the conjunctival surface of the torn lid to come out below the severed canaliculus. These sutures are then passed through the torn mesial lid tissues below the canaliculus and directed upward to engage the canthal ligament in an attempt to anchor the lid at this point. These sutures are brought out through the skin and tied over a rubber plate. (Fig. 2.) The skin and orbicularis muscle are united in layers after the depth of the wound is closed with buried gut as in the trans-marginal lacerations.

#### SUMMARY

Ocular injuries should receive immediate meticulous care. The majority of such injuries can and should be the responsibility of the physician first seeing the patient. The simplest of ocular trauma may result in loss of eyesight but this can usually be prevented by following a few simple rules of ocular care. Lacerations of the lids cannot be sutured in the same manner as simple lacerations elsewhere on the body surface. The peculiar and complex anatomy of the eyelids must be maintained if function is not to be disturbed.

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# CHEMICAL BURNS OF THE HUMAN CORNEA

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WITH the advent of the present chemical age it behooves not only the ophthalmologist but all doctors to have a working knowledge of how a chemical burn of the human cornea should be handled. Following the publication of the author's original paper in *The American Journal of Ophthalmology* (November, 1946), on this subject he has been more than amazed at the response he has had, not only from the industrial group but also from the general practitioners. It is his definite knowledge now that many of these burns are never seen by the ophthalmologist for various and sundry reasons. Let us appeal to each and every doctor to learn this treatment in detail and follow as closely as possible the routine, in case of these most dangerous of burns. The author does not present this as the ultimate in treatment but for the present it is an effective method in a vast majority of patients. Much work is being done at the present time and there is no doubt that this more or less generalized treatment will be detailed to certain definite treatments for the various chemicals.

A chemical burn of the cornea is defined as an injury which results from local contact with a chemical (solid, liquid or vapor) to such a degree that there is alteration in the structure of the cornea and conjunctiva. This alteration in structure is demonstrated by a positive stain when a 2 per cent buffered solution of fluorescein is applied. With that definition in mind let us consider the method of treatment. The author believes that it can be divided into three sections: (1) Immediate first aid, (2) secondary first aid and (3) specialized or medical treatment. The same steps apply regardless of whether the chemical is solid, liquid or vapor.

## IMMEDIATE FIRST AID

The immediate treatment of an eye burn is at the site of the accident. Specially built foot-operated eyewashing fountains are provided close at hand in every working area. (Fig. 1.) The injured eye is washed thoroughly and at once with tap water, holding the lids open with the hands. No neutralizing substances are used since study of this practice reveals that not only do they do no good but that actually some are injurious in themselves. After the preliminary washing the victim is at once transported to the medical dispensary where equipment for first aid is held ready at all times.

## SECONDARY FIRST AID

When a patient with a chemical eye burn is brought into the dispensary he is placed in a reclining chair (Beck) and tilted back over a catch basin. The eye is inspected and then anesthetized with 0.5 per cent pontocaine solution. Gross particles are removed with a moist cotton applicator. The eye is then irrigated with a continuous flow of normal saline, no pressure being exerted on the eye. Special equipment (Figs. 2 and 3) consists of a 5 gallon bottle mounted on a movable stand and equipped with a siphon (3 foot head). Irrigation is continued for fifteen minutes, after which time the eye is re-examined for gross particles and then stained with fluorescein. If the eye is damaged the injured cells will assume a typical fluorescent yellow-green stain. If a stain is observed, further anesthesia is produced with pontocaine and washing proceeds for another fifteen minutes. The stain is applied a second time and if found positive the patient is considered to have an unequivocal chemical burn and

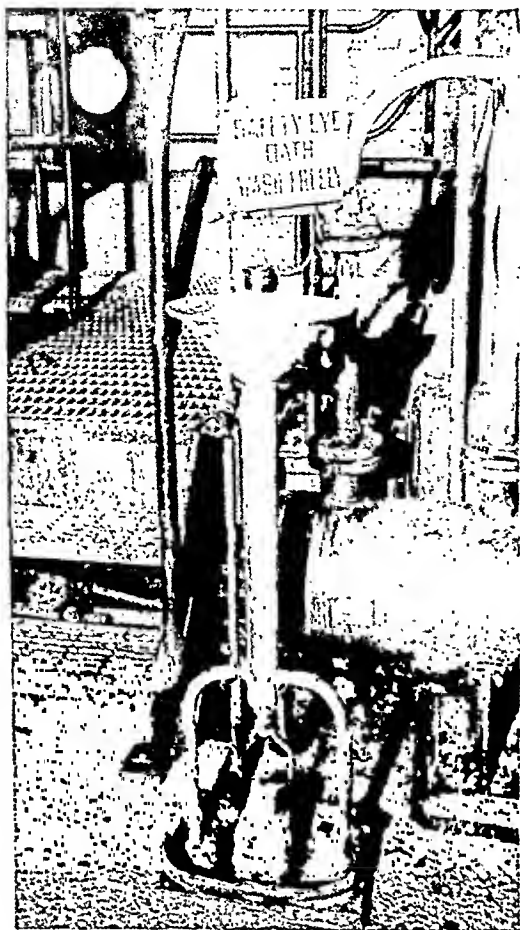


FIG. 1. The eye bath on the job.

is referred to the ophthalmologist. Time here is of importance, and it has been the writer's experience that no more than two hours should elapse between the moment of the burn and the time when special treatment is rendered. Certainly, the prognosis grows worse as time passes and a delay of six hours almost always results in some loss of vision.

#### SPECIALIZED OR MEDICAL TREATMENT

We term this technic as denuding. When the author began the study of chemical burns of the eye seven years ago, it was a debatable question whether or not some chemicals had a "delayed action." Such compounds frequently caused a loss of vision due to opacification of the cornea and adhesions of the conjunctiva following a symptom-free period of several hours after accidental contact. In searching for a scientific basis for this behavior the most

notable finding was the change in corneal structure produced by all alkaline and a few neutral organic compounds but not by acidic compounds nor those neutral chemicals which experience shows to be relatively harmless.

The corneal structure is best observed with the high power of the biomicroscope under retro-illumination, with occasional resort to direct illumination. The change consists in the presence of areas of opacity in the superficial layers of the corneal epithelium. They vary in size, possess a grayish tint and have well defined margins. They suggest keratitic deposits but direct illumination reveals that they lie immediately posterior to the precorneal film in the most superficial epithelial layers anterior to Bowman's membrane. The opaque areas are seen to be stained a faint green by fluorescein when observed by direct illumination.

We thought at first that the offending chemical had penetrated into the epithelial cells, there reacting with the cytoplasmic protein. However, this would bind the chemical in place and probably neutralize its ability to injure other cells. Studies reported by Carpenter and Smyth make it appear more probable that the foreign compound initially is physically adsorbed upon protein structures of the corneal epithelium. Following this, a portion of the adsorbed chemical denatures cellular protein which results in necrosis. The remainder is liberated slowly with its chemical nature unchanged, to diffuse from the original site of adsorption into previously unaffected tissue. Therefore, instead of a delayed effect there is a progressive action which may spread to involve the entire depth of the epithelium and eventually Bowman's membrane, at which point irreparable damage to the tissue results.

The greater number of chemicals behaving in this way are alkaline, and at first it appeared that neutralization of the compound bound to corneal epithelium would halt the progressive action. However, animal experiment demonstrated no

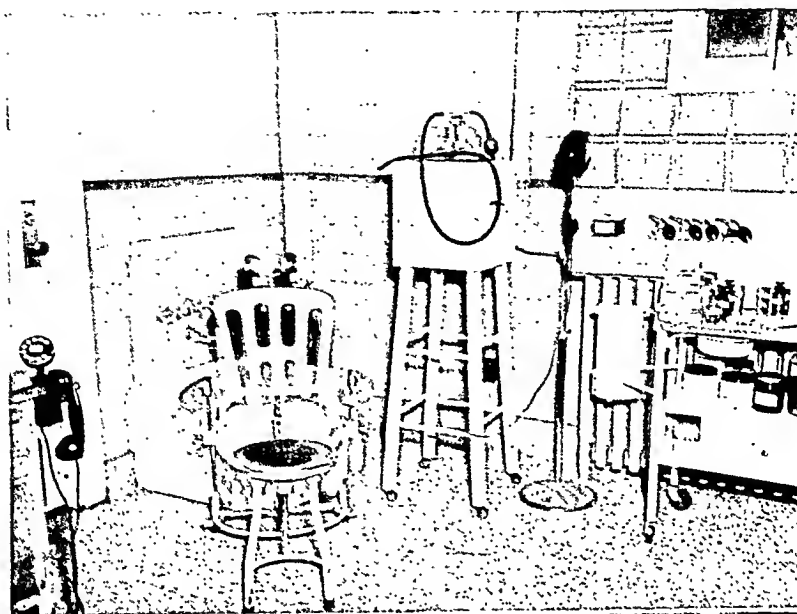


FIG. 2.



FIG. 3.

FIGS. 2 and 3. Dispensary equipment.

amelioration of injury from attempted neutralization. It was then apparent that only one form of treatment was possible, that of mechanical removal of the involved cells before a progressive action could be initiated. This operation is named "denuding." As carried out by the author the manipulation differs in purpose and thoroughness of control from débridement.

No evidence for a progressive action of acids has been observed. They apparently react rapidly with cell proteins, coagulating them and themselves being neutralized in the process. The extent of an acid burn of the cornea is, of course, determined by the amount and concentration of acid in the

eye and the length of time that elapses before it is washed out. The method generally used in treatment of an acid burn is to débride the dead tissue and treat the eye symptomatically. Following the appearance of the communication by Mann on corneal healing, the author clinically employed the methods described and concluded, in conflict with her findings, that the course of healing is not prolonged by removing destroyed tissue. Furthermore, its removal reduces secondary infection by eliminating the substrate for bacterial growth. Consequently, the author still considers débridement essential following corneal burns caused by acids.



The denuding technic in its early application consisted of complete removal of the epithelium down to Bowman's membrane. The biomicroscopic picture of the completely denuded Bowman's membrane is that of a smooth surface without evident cellular structure having regularly placed, minute dimples which are the rami perforantes of the corneal nerves. Although we have later shown that such radical removal of tissue is unnecessary, we do know that the epithelium is rapidly replaced and we have seen indications that the two methods of regeneration described by Mann are correct.

Denuding as used today removes only such tissue as is involved and the manipulation is controlled by repeated examination with the biomicroscope. The instrument of choice is a round toothpick swab. The epithelium is softened with a 4 per cent cocaine hydrochloride solution which also acts as a local anesthetic. The applicator is started in the center of the involved area with just enough pressure to distort the corneal surface slightly. With a circular motion the applicator is carried progressively from the center to the outside of the area where it is lifted. This action is repeated over the entire affected area until the biomicroscope reveals no more of the clouded cells but only a rough surface indicative of ruptured cell bodies and fragments of cells. After the corneal denuding is completed, a careful denuding of the conjunctiva is performed. Here the applicator is passed from the limbus to the cul-de-sacs, each lid swept from side to side and the cul-de-sacs finally swept. The eye is then flushed with a stainless solution of merthiolate which acts not only to remove the denuding refuse but also as an antiseptic.

Study of the eye during the denuding process may be confusing, for the pre-corneal film has been removed and allowance must be made for its absence. In the final check on the biomicroscope the meniscus of the lacrimal fluid where it meets the lower lid should be observed

carefully and no cellular debris should be left. Each eye is routinely closed with 5 per cent sulfathiazole ointment (sulfadiazene is equally efficacious) and a lid immobilizing patch is applied.

During the first consultation special attention should be given to all possible foci of infection, especially the teeth. While treatment of the foci need not be started at this time it is important that they be noted on the record. Treatment is started if the eye does not heal by first intention. It has been the author's observation that more vision has been lost in chemical burns due to focal infection than by the actual effect of the offending agent.

The after-care of the chemical burn is of great importance and the author has found that the following attention to detail will be well rewarded with satisfactory results. Warning is given the patient at the first consultation that considerable pain is to be expected due to the denuding, and each patient is provided with 0.5 per cent ophthalmic pontocaine ointment with instructions to apply it aseptically to the eye as frequently as is needed in order to control pain. Some persons, due to a difference in pain threshold, will require barbiturates and a few may need morphine. The immobilizing patch is to be worn at all times except during actual treatment.

The eyes are inspected under fluorescein stain upon the day following denudation and if found to be healing by first intention no change is made in therapy. If, however, undue reaction is found, the eye is placed at temporary rest by the instillation of a few drops of 5 per cent homatropin solution and 5 per cent sulfathiazole ointment is added at four-hour intervals. The choice of homatropin is made so that loss of time, an important factor in industrial practice, will be minimized if the eye heals promptly.

On the third day inspection is again made and if healing is not complete, there is presumptive evidence that the burn has converted to an infected ulcer and active combative treatment is instituted. The eye



itself is sprinkled with methylene blue powder and the excess flushed away. Ponto-caine, sulfathiazole and the immobilizing patch are continued. An intramuscular injection of 4 cc. of proteolac\* is given and administration of maximum doses of sodium salicylate is started. Dental x-ray or medical examination of other foci is made and such areas, if amenable to treatment, are removed at the earliest possible moment, regardless of the condition of the eye. In the event that surgical treatment of foci is to be undertaken the patient is hospitalized and intravenous typhoid vaccine fever therapy is begun. The surgical procedures are so arranged that they fall on the rest day in the typhoid series. At this point the eye is atropinized, since prevention of time loss is no longer a factor to be considered and the whole attention must be turned toward the healing of the eye.

After healing has taken place and the cornea has been free from fluorescein staining areas for forty-eight hours, any residual opacity is treated with increasing

percentages of dionin or with choline chloride.

Case reports have been recorded elsewhere and will not be repeated here. The author's series now totals nearly 800 patients and he believes that he can fairly state that all losses of vision from chemical burns can be explained on the basis of failure of this reported technic in one or more of its details.

#### CONCLUSIONS

1. Immediate first aid followed by long flushing with water is of the utmost importance. No attempt at neutralization is recommended.
2. Specialized treatment by an ophthalmologist should be given within two hours after the injury. Further delay threatens recovery of full vision.
3. Denudation is the treatment of choice.
4. There is no mention made of conjunctival adhesions in this article and it is notable that with the technic described the author had no such complication in any of these nearly 800 consecutive patients.

\* G. D. Searle & Company.



## FRACTURES OF THE OS CALCIS

## PRELIMINARY REPORT

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THE os calcis is fractured more frequently than any other tarsal bone and in various series represents 1 to 2

found both by x-ray studies and by exposure of the fracture at operation to be on the medial aspect and it is here that dis-

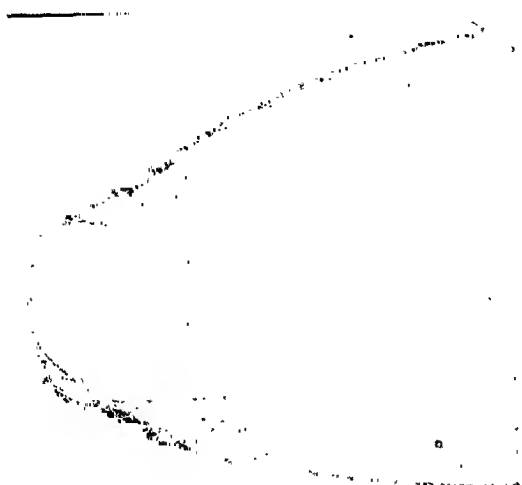


FIG. 1. X-ray of the os calcis at the time of the fracture revealing a typical lateral displacement of the tuberosity and interposition of the corticle fragment.

per cent of all fractures. Willis C. Campbell once said that mal-union in fractures of the os calcis is so common as to be almost the usual result. In recent studies it has been determined by the use of high speed photography that the fracture is produced by the foot striking the ground in a pronated position with the tuberosity of the os calcis outward, backward and downward. The tuberosity tends to be carried upward, outward and forward, resulting in the sustentaculum being displaced downward and the long arch of the foot being flattened.

The anterior spicule of the lateral fragment produces a prominence beneath the external malleolus and this tends to persist, even after the strongest traction by pins through the os calcis and the tibia. However, the greatest deformity has been

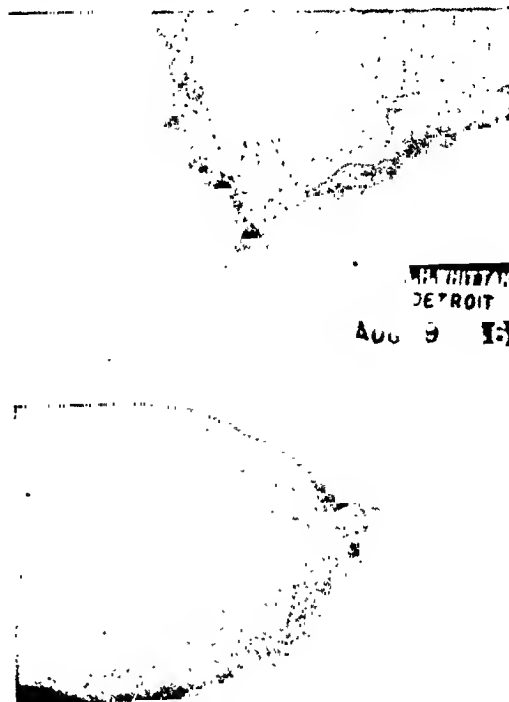


FIG. 2. Anatomic end result obtained by open reduction.

placement of the fragments and interposition of a brittle fragment of the cortical bone blocks anatomical reposition.

This interposition of the fragments results from the cortex being brittle and thin, the remainder of the bone being cancellous and the explosive force of the fracture results in fragmentation of the cortex, the fragments being rotated and being driven into the cancellous portion. The posterior process is forced laterally and forward to produce a widening of the bone and foreshortening.

All of the methods which have been suggested since the time of Dr. Frederick

Cotton have failed to produce a good anatomical reposition, and feeling that an arthrodesis of the subastragaloid joint is too disabling in the case of a man who has to perform heavy labor and also feeling that the more radical procedure of excision of the bone also results in too great a disability, during the past year open reduction has been performed upon the os calcis.

At operation the mechanical blocking due to interposition of the cortical fragments has been found and with the removal of these fragments good anatomical position has been obtained. This also results in a smooth, articular surface in the subastragaloid joint.

This type of treatment has resulted in disability of four months in the severely comminuted and displaced fractures, in contrast to the two years previously esti-

mated as the immediate disability and although a mild arthritis may develop after the years go by, in these patients the function which has resulted during a year of observation would indicate that a high percentage of partial permanent disability can be greatly lessened.

#### CONCLUSIONS

1. The difficulty of obtaining a good functional result in fractures of the os calcis is noted.
2. The mechanism of the fracture and the displacement is outlined.
3. The anatomical position obtained is shown by x-ray studies.
4. The possibility of obtaining a good functional result by open reduction is presented.



# New Instruments

## FINDER AND SCREW DRIVER USED IN DRIVING SCREWS WITH A DRILL

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IT has been the experience of the author and undoubtedly that of many orthopedic surgeons, that the usual method of inserting screws into plates or into time and materially lessen the shock to the patient, it was felt that emphasis upon a mechanical means to drive screws should be made.

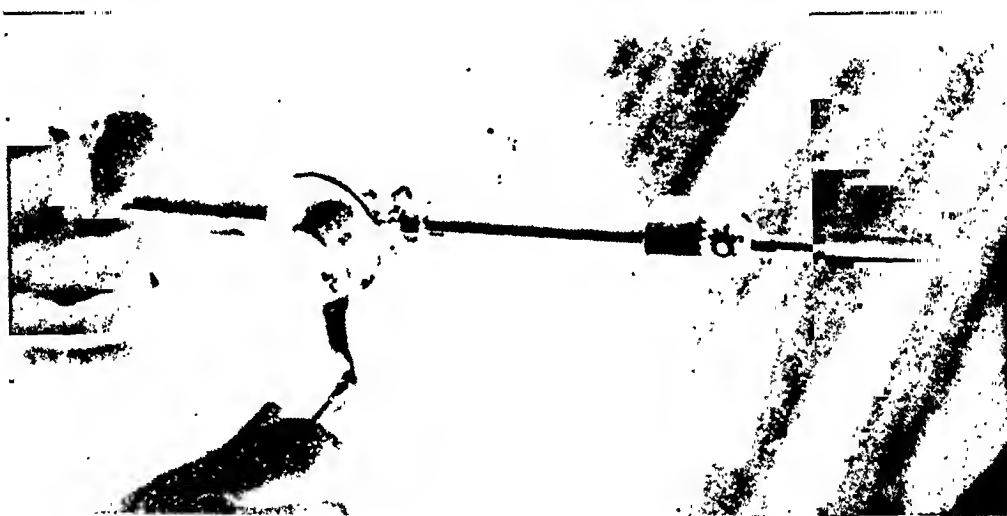


FIG. 1. Screw driver and finder.

grafted bone, is quite a tedious chore. In addition to the length of time required to place a number of screws into bone, there is often a considerable amount of irritation to the palm of the hand when considerable pressure is made against the screws, even though we know a correctly handled screw driver is gripped on its side, not over the back.

Not alone therefore because of the work required, nor because of the discomfort even to twisting and avulsing palmar skin that becomes caught in the glove, but also because a rapid mechanical method would also appreciably shorten the operative

With this in mind, we first used the end of a screw driver and placed this in the Jacob's chuck of a hand drill. We found that we could quite easily drive screws in, but occasionally the screw driver would slide out of the slot, also the apparatus made a rather cumbersome thing to first engage the slot of the screw. This was simplified by using a Phillips head screw, but still the need of a combination finder and screw driver became apparent.

Under the assumption that in modern manufacturing methods, there must be some way whereby the slots of screws are found and the screws automatically

screwed in by power tools, we assumed an apparatus containing a sleeve around a screw driver, the sleeve upon a spring, the screw driver to rotate within the sleeve. We looked around and found precisely this. The hexagonal base of this screw driver\* allows it to engage in the chuck of the drill with ease and without requiring strong tightening of the chuck and there would be no slipping of the screw driver. The spring connecting the screw driver and the finder is just tense enough so that when the screws are merely placed in previously drilled

holes in the bone, adequate pressure can be made to keep the screws in line. As the drill is spun the screw driver inside of the conical finder turns into the slot of the screw and then with no difficulty the screws can be driven in until they are fully tightened. As a matter of fact they can be tightened with a good drill to a point even beyond that possible by hand, for the drill gives a mechanical advantage.

The author dismantles these stock screw drivers and finders and has all parts chromium plated in order to better preserve the material.

\*The "Screw Driver and a Finder" No. 17690, is made by Black and Decker.



# SELF-RETAINING SKIN HOOKS\*

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TO a large proportion of patients the scar resulting from an operative procedure is of major importance, espe-

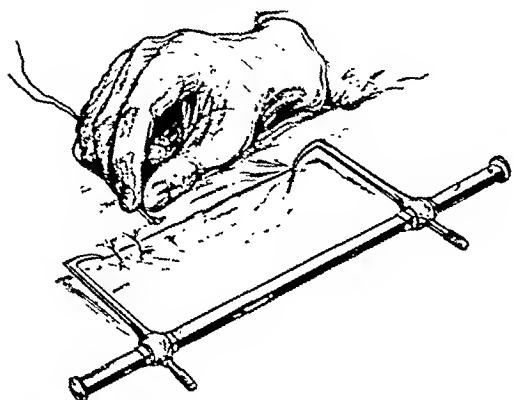


FIG. 1. Illustration of self-retaining skin hooks.

cially if it is on an exposed part of the anatomy. Erroneously or not, they often judge the entire surgical procedure by the appearance of the skin incision. Because of the importance of the skin closure an aid for easier and more accurate skin closures was devised. It is a common practice for the busy surgeon to leave the closure of the operative wound to his assistants, thus leaving to two people a task which often requires three. In many individuals, especially the obese, there is often distortion and gaping of the wound even after the approximation of the subcutaneous fascia and tissues. The usual skin hooks are manually held, applying tension to each end of the wound, thus causing the two edges of the wound to come together. Since they are held by an assistant, he is lost as an aid to the actual closure of the wound and is often a hindrance because one of his

arms is in front of the surgeon. This loss often becomes evident in the result and in the amount of time required to complete the closure. Our skin hooks are designed to liberate the assistant so that he may participate more actively in the closure.

The self-retaining skin hooks illustrated (Fig. 1) employ the tension-lock principle common to many other instruments, among them the Frazier laminectomy retractor and a self-retaining retractor recently designed by ourselves.<sup>1</sup> In addition, however, locking thumb screws have been applied to the two freely movable arms so that marked tension is not necessary to maintain the instrument in the position desired. The skin hooks are applied to each end of the wound and are then separated with adequate tension so as to approximate the two edges of the wound. If the wound is long, curved or sharply angulated, the instrument can be applied to one segment of the wound at a time. The bar is 12 inches in length, making the instrument adequate for most incisions commonly employed. The bar is also conveniently removed to one side facilitating the placement of the sutures.

The self-retaining skin hooks here described are designed for the accomplishment of more cosmetic skin closures with greater facility. This aim has been realized by us in the closure of devious types of skin incisions on a busy surgical service.

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\* From the Second Surgical Division (Cornell), Bellevue Hospital, New York, N.Y.

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## Editorial

### METAMORPHOSIS OF CANCER OF THE PROSTATE

**A**N unusual experience in the progress and regression of this so-called incurable disease, with demonstrable metamorphosis of a prostatic cancer following stilbestrol therapy, has suggested significant changes in the surgical management of prostatic cancer.

It has been estimated that possibly one of every eight males over forty-five years of age will develop this disease. Examination of the prostate gland in routine autopsies reveals an incidence of cancer of this organ of 14 to 18 per cent, if not more. In fact, in cases of prostatic obstruction, the incidence of cancer appears to be as high as 20 to 25 per cent. The prostate is affected more frequently than any other organ. Since there can be no causal therapy—the etiology of cancer being unknown—treatment must be directed toward complete removal of the tumor or to alleviation of the symptoms produced. The ideal and hitherto only curative treatment consists of radical perineal prostatectomy. Unfortunately, since this cancer is asymptomatic in its early stages, very few patients apply for treatment before the cancer has invaded the capsule of the gland and metastases have developed. Very tiny cancers can be detected by rectal palpation, and this procedure should be a routine measure since diagnosis in this very early stage permits hope of definite cure by radical

operation. Later when symptoms of urinary obstruction develop, the growth will have become so hard and large, so fixed and densely adherent to surrounding structures that the surgeon cannot even get near enough to attack the lesion, which therefore becomes technically inoperable.

Less than a decade ago, statistics and clinical experience showed that only about one-tenth of cases of cancer of the prostate referred for treatment were operable, in the sense of being amenable to radical perineal prostatectomy. In the other 90 per cent of cases, the only treatment offering some relief of pain and obstruction and a slightly longer survival, was transurethral resection. This surgical intervention exposes the patient to a major operation without hope of cure. By this route there is no access to the posterior lobe of the prostate, which is the most common site of the lesion. The cancer still remains in the body, and after a longer or shorter interval pursues its course to the inevitable fatal termination.

A lower immediate operative mortality and a longer survival can be achieved by using either the total or radical perineal operation than with the suprapubic or transurethral operation. Once the tumor had extended beyond the capsule, there was formerly no real hope for the patient. All that could be offered him was relief of symptoms by suprapubic cystostomy or a

transurethral resection with survival for a few months or years. Only by proper training of all medical students in rectal palpation of the prostate gland and its routine application to all patients over fifty years of age applying for physical examination, and the careful training of surgeons in performance of all types of radical perineal prostatectomy, so that transurethral resection does not become a makeshift because of its simpler technic, can we hope to obtain earlier diagnoses and an increase in the number of actual cures.

Recently the advances in biochemistry and endocrinology have accumulated so swiftly, and their new applications have appeared so manifold and so rich in possibilities, that in our eagerness to benefit by them we momentarily lose sight of the fact that only time, and literally a period of many years, can provide the necessary test of their real value.

One of these most sensational advances was the discovery of the effect of the sex hormones on the metabolism of cancer cells. In cancer of the prostate, administration of stilbestrol also produced a reduction in the size of the gland and a softening of its stony hard consistency. Castration had a similar effect. These results immediately reversed the operability statistics, opening a new avenue of possibilities for more radical surgery, so that now, even though patients still report for treatment as late in the course of the disease as formerly owing to lack of symptoms, nearly 80 per cent can be rendered fit for radical perineal prostatectomy by proper preoperative preparation of the patient with stilbestrol. This is indeed a great advance from the earlier operability of 10 per cent.

Once diagnosis of prostatic cancer has been established, the patient should be started at once on a course of stilbestrol therapy, beginning preferably with small doses, in order to permit the organism to become adjusted. For the first month the patient may be given a dose of  $1\frac{1}{2}$  gr. of stilbestrol (diethylstilbestrol) three times daily, and during the second month 1 gr.

three times daily. By this method of procedure, unpleasant by-effects of the hormone therapy, such as gastric disturbances, hot flashes, swelling of the breasts, etc., may be avoided. Other beneficial effects of the treatment include relief from pain, diminished frequency, reduction of the amount of residual urine and urinary disturbances. Not infrequently a reduction in size or disappearance of metastases also occurs.

This period of preparation for the radical operation can be utilized to increase the patient's resistance also in other ways. Urinary antiseptics can be administered to combat infection, frequently associated constipation can be properly treated and anti-anemics can be administered, as well as a strengthening diet and abundant vitamins, in particular vitamin B complex. In this way the patient is built up not only to withstand the shock of the operation but to gain bodily resistance as well as a certain degree of immunity against the deleterious toxic effects of the carcinogenic elements. An index to check the response to stilbestrol therapy is provided in the routine urologic follow-up and in the determination of serum acid phosphatase which drops to normal shortly after beginning of treatment. Thus by correcting the disturbed cellular metabolism and improving the general condition of the patient, with the gland diminished in size and softened, radical perineal prostatectomy is no longer contraindicated.

It must be emphasized and has been proved clinically and anatomopathologically that the improvement gained by castration or administration of stilbestrol, or both, continues only for a certain limited period, after which the cancer again gains the upper hand and proceeds on its destructive course. Obviously if the cancer is totally removed during the period of improvement, there will be less chance for recurrence than following partial removal of the obstructing portion of the gland as accomplished by transurethral resection. At this point of optimum improvement fol-



lowing stilbestrol therapy the patient stands at the cross roads. If he chooses the road of radical perineal operation, he may be cured. If not, death from cancer is his inevitable fate.

That hormone therapy actually produces changes not only in the gland but in the cancer tissue itself has been shown in serial biopsies taken during the treatment period. In one remarkable case, the author had the exhilarating experience of observing *complete disappearance* of cancer of the prostate and of its pulmonary metastases following stilbestrol therapy. The patient died of intercurrent disease and autopsy revealed no trace of the prostatic cancer which had been demonstrated in needle biopsy specimens, nor of the roentgenologically diagnosed pulmonary metastases.

A brother of this patient, whose father, mother and four sisters died of cancer, had a hard, enlarged prostate suggesting cancer, but needle biopsy yielded negative results. However, as metastases developed a transurethral resection was done. Histologic examination of twenty sections of the tissue removed from the two lateral lobes and the middle lobe of the prostate showed no evidence of cancer but only lesions characteristic of benign adenoma and chronic prostatitis. However, after three subsequent transurethral resections for relief of urinary symptoms, the patient died of cachexia and metastases to the chest and bones. He had refused castration and finally died from the disease primarily located in the posterior lobe of the prostate.

In citing the first mentioned case of clinically and anatomically proved primary cancer of the prostate, in which autopsy following stilbestrol therapy revealed no sign of malignancy, we wish to emphasize the fact that this is still only one single case. For the present we can hold out no hopes for cure of the disease except by radical surgery. Until such time as further progress in the experimental and clinical study of these phenomena bear fruit, with possible prolongation of the period of amelioration or even eventual cure, our

best course would seem to be to utilize to its fullest extent the beneficial action of stilbestrol; and then before this begins to wane, to seize the opportunity for radical perineal operation under optimal conditions, thus ridding the patient of his cancer and offering him a chance of real cure.

Primarily because of the real scarcity until recently of operable cases and not infrequently because of inadequate training and experience, it has become the custom in many clinics to refer patients with prostatic cancer for transurethral resection. It is to be hoped that with this new shift in operability statistics and new technical possibilities, there will be a trend toward more frequent use of total or radical perineal prostatectomy, which even in the days before the advent of hormone therapy could salvage 50 per cent of otherwise doomed patients.

These findings suggest that the ideal moment for a total perineal prostatectomy or a radical perineal prostatico-vesiculectomy is the time when the described metamorphosis of the malignant process has taken place.

The operation for radical perineal prostatectomy is simple and may follow any one of the three different classic technics, according to the extent of the cancerous involvement of contiguous anatomic structures: (1) When the carcinoma is limited to the prostate, the whole prostate and its capsule should be totally removed with a subsequent plastic anastomosis of the membranous urethra to the vesical orifice. (2) When the carcinoma of the prostate has involved the seminal vesicles, the operation, in order to remove as much as possible of the cancerous lesion, should be a total prostatico-seminal-vesiculectomy followed by the same type of anastomosis as described above. (3) When the carcinoma of the prostate has extended to infiltrate the neck of the bladder and the seminal vesicles, the more radical procedure of Young is indicated with removal of the prostate, the seminal vesicles and the bladder neck, and

anastomosis of the membranous urethra to the remaining portion of the bladder.

Any one of these types of radical perineal prostatectomy has its true clinical indications in a group of well selected cases and indeed the operative technical possibilities appear to be more satisfactory nowadays due to the metamorphosis produced by pre-operative hormone therapy. With this new attitude, most cases will be rendered operable by the first and most conservative of these three technics mentioned.

In the future, all inoperable cases of prostatic cancer, instead of being referred for immediate transurethral resection, should be given the benefit of two or three months of stilbestrol therapy combined with routine conservative medical and urologic treatments, which may render them suitable for radical and curative perineal prostatectomy, and which at least would have the same palliative effect as the otherwise futile transurethral resection. Stilbestrol

therapy is also preferable to castration as a preparation for radical operation, since it offers about the same degree of amelioration without mutilation and psychic insult.

Considering this remarkable rôle played by the sex hormones in influencing the metabolic cellular dysfunctions in cancer of the prostate, the possibility of a future prophylactic utilization of stilbestrol to prevent the development of prostatic cancer and reduce its incidence seems not too remote.

While in no way belittling the rôle of this new treatment in affording relief from pain and a more comfortable and somewhat longer survival to patients who can no longer be helped by radical operation, still the most significant contribution of stilbestrol therapy to prostatic cancer to date consists in widening the indications for radical perineal prostatectomy, the only curative therapy that we possess.

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# Original Articles

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## THE RELATIONSHIP OF THE VAGINA TO ADJACENT ORGANS IN RECONSTRUCTIVE SURGERY\*

### A HISTOLOGIC STUDY

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THE relationship of the vagina to the urethra, bladder, cervix, anorectal canal and perineal body in the normal and in the relaxed state is a matter of vital importance to the gynecologist. A clear understanding of this relationship facilitates reconstructive vaginal plastic surgery and enhances permanently better anatomic and physiologic function. Though a knowledge of this relationship is basic, there has been a perennial controversy hinging on the existence or non-existence of a surgically useful and indispensable fascia for reconstruction purposes. *This study deals with the microscopy of the tissues between the vagina and the adjacent pelvic organs in their undisturbed state*, since only a microscopic investigation can lead to ultimate precision in the designation and classification of these tissues. This type of study is not new, several observers having approached the problem from the same angle, drawing varying conclusions from their studies of isolated specimens. Jacob Henle,<sup>1</sup> in 1866, approaching the problem as a histo-anatomist rather than as a gynecologist, came forth with the first free hand histologic drawing of a cross-section extending from the mucosa of the bladder to the mucosa of the vagina, and labelled the various tissues as vesical epithelium, submucosa, layer of circular bladder fibers, layer of longitudinal bladder fibers, loose cellular tissue, layer of circular vaginal fibers, layer of longitudinal vaginal

fibers, submucosa and vaginal epithelium. It is to be noted that between the musculature of the bladder and that of the vagina Henle found "loose cellular tissue." The value of Henle's drawing was first recognized by H. C. Coe<sup>2</sup> who reproduced it in his chapter on the anatomy of the pelvic organs in the first volume of "A System of Gynecology by American Authors" (1887).

The first to speak of the tissue separating the bladder from the vagina as a "loose areolar" was T. Gaillard Thomas<sup>3</sup> in 1872. Whether he had seen it under the microscope is not clear, but in a detailed description of an operation on the sagging anterior vaginal wall, he stated that the director was gradually insinuated through the loose areolar tissue between the bladder and the vagina until it reached a point near the urethra.

The above references are the only contributions to the literature of this subject during the nineteenth century. In 1910, in the first edition of his text, "Principles of Gynaecology," W. Blair Bell<sup>4</sup> included two photomicrographs, clearly demonstrating loose connective tissue between the musculature of the vagina, the juxtaposed musculature of the bladder above and the musculature of the rectum below. However, in his text he erroneously assumed a similar relationship between the urethra and vagina. Three years later (1913) M. Moritz<sup>5</sup> reproduced a cross-section of a fetal pelvis prepared by H. Platt, which

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showed an areolar separation between the rectal and vaginal walls and a complete fusion of the musculature of the urethra and the vaginal wall. Platt's original contribution was not found after careful search at the Library of the New York Academy of Medicine.

In 1926, A. B. Spalding<sup>6</sup> in his presentation on hemostasis in vaginal hysterectomy for procidentia, dealt with the histology of what he called the fascia endopelvina, adding that it developed by mesothelial condensations around the ureters, the pelvic nerves and blood vessels. Four microscopic slides were included; one (low power) demonstrated all tissues between the mucosa of the vagina and that of the bladder, but the various types of tissues were not differentiated. In the remaining three slides the preservation of relationship between organs was not maintained. Rather, Spalding demonstrated the muscular layers of the vagina and of the bladder independently, in both instances erroneously labelling the muscular tissue as vesicovaginal vascular fascia. Thus, contrary to fundamentals, he assumed that a fascia was both a muscular and vascular structure. Ignoring all basic histologic concepts, Spalding reiterated this view in his discussion of Goff's presentation in 1931, stating that the fascial layer between the bladder and the vagina was a "distinct layer of musculofibrous tissue which was quite vascular."

A classic contribution to the histologic study of the tissues between the vagina and the juxtaposed pelvic organs was by B. H. Goff<sup>7</sup> in 1931. He bisected a specimen consisting of uterus, bladder, vagina, urethra, rectum, anus, vulva and perineal body removed *en masse* from a nullipara, twenty-seven years of age who had died of a thoracic injury. He made seven cross-sections at right angles to the vagina, three through the posterior and four through the anterior vaginal wall. Thus he was able to note all the tissue between the mucosa of the vagina and that of the rectum, anal canal, urethra and bladder. From these

cross-sections, Goff was able to demonstrate microscopically that there was a "thin layer of fascia of the areolar type" between the anterior vaginal wall and the wall of the bladder, between the posterior vaginal wall and the wall of the rectum. No "fascia of the areolar type" was demonstrable between the musculature of the anterior vaginal wall and urethral wall, and none between the posterior vaginal and anal wall. He concluded that the "layer of areolar fascia" which separated the anterior vaginal wall from the bladder wall (vesico-vaginal fascia) and the "layer of areolar fascia" which separated the posterior vaginal wall from the wall of the rectum (rectovaginal fascia) united at the sides of the vagina to form the perivaginal fascia, which formed the "fascia endopelvina." But he stated specifically, that the successful correction of cystocele, rectocele and urethrocele depended on utilization of the tissue of the vaginal wall rather than this "fragile areolar fascia." Goff's clarity was marred by his insistence on calling meshed areolar fibers a *fascia*. In reality, this intervening areolar mesh consists of loosely scattered and tangentially interwoven connective tissue fibrils of a spider web texture; it is not sheet-like, is entirely devoid of tensile strength and calling it a *fascia* has perpetuated a misconception.

N. P. Sears<sup>8</sup> (1933) slides dealing with the microscopy of the vaginal wall and lateral tissue did not preserve the relationship of pelvic organs in all instances. He dealt with the "fascial plane surrounding the vagina." With this loss of relationship, Sears' microscopy was limited to the musculature of the vagina and some loose lateral areolar tissue, and consequently his study remained inconclusive. He called some of the layers of the vaginal musculature, fascia. He also included "a section through the cervix, vagina, rectum and connective tissue" from the perineum of a two year old child, and in this slide the areolar nature of the tissue between the vagina and rectum is plainly visible. There is also a cross-section through the vagina

and rectum in a specimen removed from an eight months old infant, and here again the nature of the tissue between these organs is definitely areolar.

H. Koster,<sup>9</sup> in 1933, removed *en masse*, the uterus, adnexa, bladder, vagina, urethra and the loose areolar connective tissue constituting the parametrium from a multipara, thirty-one years of age, with no signs of prolapse or retrodisplacement of the uterus. Though Koster featured the microscopy of the parametrial tissue, he stated that a longitudinal section of the vagina and rectum extending "from the upper end and running down to the perineum" proved that the vaginal wall was separated from the rectum only by loose areolar connective tissue. In the section including the vagina and bladder in median line, the wall of the bladder was separated from the cervix and vagina by a similar type of tissue. He added, significantly, that since his findings tallied with those of Goff (1931), he did not deem it necessary to present any illustrations.

The present investigation has been undertaken primarily to clear up the question of fascial sheets which are variously designated, "isolated" and "utilized" by gynecologists as supporting structures in the repair of bulging anterior and posterior vaginal walls. Is there or is there not a true fascia of indispensable surgical worth? The answer cannot be disposed of on the basis of an equivocal terminology. As a basis for discussion, a crystal clear understanding of the term fascia is necessary. Returning to fundamentals, the histologists are somewhat averse to the use of the term fascia, preferring the composite designation "dense and regular connective tissue," depending on variations in structural constituents. The histologists admit that a clear-cut classification is difficult and inexact, inasmuch as the different types of connective tissues present transitional forms. Structurally all connective tissue consists of cells or fibroblasts, white or collagenous fibers, elastic or yellow fibers and an amorphous ground substance.

These basic elements vary in amount and in arrangement. In the fascias, aponeuroses and tendons, the collagenous bundles and fibroblasts are arranged regularly in sheets. In each sheet, the fibers follow a parallel and often slightly wavy course.

Independent of these sheets, membranes, or fascias of connective tissue, there is another type, also of mesenchymal origin but morphologically different—the areolar tissue, which is classified as a loose connective tissue. On this point, A. Maximow and W. Bloom<sup>10</sup> state that after all other types of connective tissue have been formed, the remaining mesenchyme develops into a loose tissue which contains almost all the cellular and intercellular elements occurring in the specialized types of connective tissue. This loose tissue packs the spaces between the organs and surrounds vascular lymphatic channels and nerve elements. It is a whitish "sticky" mesh, easily torn during dissection. Like a collapsed sponge, it contains innumerable minute cavities which can easily be filled artificially with liquid or air (the cellulæ of the old anatomist) and which gave rise to the term areolar tissue. In brief, a fascia is a covering or enveloping membrane; areolar tissue is a packing or filling material.

This study is based on the microscopy of twenty-two specimens, each consisting of the fundus, cervix, urethra, vagina, rectum, anal canal and perineal body removed *en masse*. Of these specimens, four were removed from fetal cadavers of four, six, eight and nine months of intra-uterine life, respectively; three specimens were removed from the cadavers of infants—six, twelve and nineteen months of age; the remaining fifteen specimens were removed from adult cadavers—twenty, twenty-four, twenty-five, thirty-one, thirty-four, thirty-seven, forty-one, two of forty-two, forty-three, forty-seven, sixty, sixty-two, sixty-seven and seventy-two years of age, respectively. Only the cadavers presenting no visible evidence of pelvic lesions were selected. Death was due in each instance to

an extragenital, extrapelvic lesion. One specimen was removed from the body of a twenty year old patient, who died during the third month of pregnancy from an "acute infectious hepatitis." Specimens were placed in fixing fluids. In some instan-

TABLE I  
SERIES OF SPECIMENS REMOVED FROM CADAVERS

Case	Age	Color	Parity	Cause of Death
1.	4 mo. fetus	White		Atelectasis
2.	6 mo. fetus	White		Atelectasis
3.	8 mo. fetus	White		Atelectasis
4.	9 mo. fetus	White		Subarachnoid hem.
5.	6 mo. old infant	White		Bronchopneumonia
6.	12 mo. old infant	White		Unknown
7.	19 mo. old infant	White		Meningitis
8.	20 yr.	White	3 mo. pregnant	Ac. inf. hepatitis
9.	24 yr.	White	Nullipara	Rheumatic heart disease
10.	25 yr.	Colored	Nullipara	Stab wound
11.	31 yr.	Colored	Nullipara	Gun shot wound
12.	34 yr.	White	Multipara	Poisoning
13.	37 yr.	White	Multipara	Poisoning
14.	41 yr.	White	Nullipara	Pneumonecrosis
15.	42 yr.	Colored	Para viii	Bronchopneumonia
16.	42 yr.	Colored	?	Cerebral accident
17.	43 yr.	White	Nullipara	Bronchogenic ca
18.	47 yr.	White	Nullipara	Unknown
19.	60 yr.	White	Multipara	Heart disease
20.	62 yr.	White	?	Embolism
21.	67 yr.	White	Multipara	Pulmonary T.B.
22.	72 yr.	White	Multipara	Cirrhosis

ces, the urethral, vaginal and anorectal canals were packed with cotton. The relationship of the vagina to the surrounding organs was maintained in all instances. Two specimens were embedded in paraffin and the remainder in celloidin. Some specimens were subjected to serial cross-sections; some to serial sagittal sections and others to both, after an accurate bisection. Each section was made so as to demonstrate all tissues intervening between, and including, the mucosa of the vagina and the mucosa of one or more adjacent organs, i.e., all tissues between the mucosa of the vagina and that of the urethra; the vagina and the bladder; the vagina and the anal canal; the vagina and the rectum. The tissues were subjected to hematoxylin eosin, to Verhoeff's elastica stain and Van Gieson's connective tissue stain. Approximately 1,200 slides were stained and studied.

## MICROSCOPY

For the purposes of clarity and brevity, some general features of the histology of the organs involved can be pointed out. The urethra and bladder are lined with transitional epithelium, only the urethral orifice having a variable amount of squamous epithelium. The vagina is lined with squamous epithelium. Neither the urethra nor the vagina has a true submucosa and the epithelium lies directly upon a *substantia propria*. The rectal wall conforms to the usual description—mucosa, submucosa, inner circular and outer longitudinal muscular coats. The epithelium of the anorectal area covers the posterior surface of the perineal body.

*Specimen 1. Four months' fetus: (Case 1).* This specimen consists of serial cross-sections of all the pelvic organs from the perineal body up to and including the bladder. The entire wall of the vagina is a tightly woven fibro-elastic-muscular structure. The *substantia propria* is connective tissue, moderately vascular and rich in fine and coarse elastic fibers. The muscle which forms the outer portion, consists of circular and longitudinal bundles and does not completely encircle the vagina. The muscle is heavier laterally and posteriorly in the mid-vagina; it is very inconspicuous anteriorly and becomes lost superiorly in the fibro-elastic vaginal wall at the fornices and inferiorly near the orifice. It is slightly vascular and rich in elastic fibers. The circular muscle fibers form a very thin distinct inner layer near the fornices and in the lower vagina. In the mid-vagina, the circular and longitudinal bundles intermingle; inner and outer layers are not distinct. No lymphatic tissue is found. There are a few glands near the external *urethral orifice*, but none are found in other regions. The urethral *substantia propria* is a dense, vascular, connective tissue rich in elastic fibers. The muscular wall consists of involuntary circular fibers, not forming a solid wall but broken into strands by fibrous and elastic tissue. The upper urethra and vesical neck are enclosed by a circular muscle bundle, heavy anteriorly and thinning out laterally and posteriorly where it is intimately associated with the bladder muscle of the trigone and cannot be distinguished from it. Above the

base of the bladder the wall is of very loose texture with an abundance of loose areolar tissue separating the bundles in which are intermingled circular, longitudinal and oblique fibers.

*Summary.* There is a complete fusion between the urethra and vagina from the base of the bladder to the external urethral orifice. There is no line of demarcation between these two structures. Above the internal urethral orifice the bladder wall is separated from the upper vaginal wall by loose areolar tissue. Posteriorly, the rectal and vaginal walls are separated by a distinct zone of loose areolar tissue. (The perineal body is not included in these sections.)

*Specimen II. Six months' fetus: (Case 2).* One-half of the specimen is cut serially in sagittal section; one-half is cut serially in cross-section. *The substantia propria* of the vagina is a dense fibrous layer, moderately vascular and rich in elastic fibers. Near the vaginal orifice there is some oblique voluntary muscle in the outermost portion. The remainder of the vaginal wall is involuntary muscle not arranged into distinct layers but forming a mesh-work of longitudinal and circular muscle fibers, elastic and connective tissue. There is a bare suggestion of a circular coat only in the lower one-third. The muscle of the mid-vagina is heavier posteriorly and laterally and becomes scanty anteriorly. At the level of the vaginal introitus and superiorly at the fornices the muscle becomes lost in connective tissue. No lymphatic tissue is found.

The urethral *substantia propria* is a dense vascular connective tissue rich in elastic fibers. There is an outer involuntary muscle, indistinctly circular and broken up by dense connective and elastic fibers. At the external meatus there is a fairly distinct small band of circular voluntary muscle. At the internal orifice is a distinct band of involuntary circular muscle which fits around the base of the bladder and upper urethra. Anteriorly, it is a heavy muscle and fades out into a much thinner muscle posteriorly. It fuses with the inner muscular coat of the bladder superiorly. At the level of the internal os the outer muscle layer of the bladder lies external to this muscle bundle. There are a few glands in the upper urethra lined by transitional epithelium.

The *perineal body* consists largely of voluntary muscle. The lowermost portion has

abundant loose areolar tissue, elastica and fat. In the upper portion it is much more compact and fuses tightly with the vaginal and anal walls.

*Summary.* The urethrovaginal wall forms a solidly fused structure from the clitoris up to the base of the bladder where the bladder and vagina become separated by a loose, avascular, areolar zone. The vaginal and rectal walls are separated by a distinct areolar zone down to the apex of the perineal body, which fuses the lower vagina with the muscular coats of the anorectum.

*Specimen III. Eight months' fetus: (Case 3).* This specimen consists of serial cross-sections of all the pelvic organs from and including the perineal body and anal canal up to and including the bladder. *The substantia propria* of the vagina is a dense, moderately vascular connective tissue and elastica. The involuntary muscle wall has both longitudinal and circular bundles not distinctly separated into two layers, although the inner bundles are more frequently longitudinal than the outer, woven together by dense elastica and connective tissue fusing the vaginal wall into a solid structure. The circular muscle fibers are most abundant in the middle third where they are more prominent laterally and posteriorly and scanty anteriorly. At the upper and lower ends all fibers are lost in fibro-elastic tissue. No lymphatic tissue is found.

The urethra has a compact *substantia propria* rich in elastica and a circular layer of involuntary muscle. At the base of the bladder there is an extremely heavy involuntary muscle separated into large bundles by compact connective tissue rich in elastica.

*Summary.* The urethrovaginal wall forms a solid, compact structure from the external orifice to the base of the bladder. Just above the level of the internal urethral orifice there is a beginning line of separation by loose, avascular, areolar tissue. The vaginal and rectal walls are separated by a distinct loose areolar zone down to the apex of the perineal body, where they are tightly fused into a compact structure.

*Specimen IV. Full term fetus: (Case 4).* The serial cross-sections of a specimen removed *en masse* consists of perineal body, anal canal, rectum, urethra, vagina, bladder, cervix and uterus. *The substantia propria* of the vagina is compact, connective tissue moderately vascular



and rich in elastica. The muscular wall is involuntary in type, arranged largely in circular bands, some longitudinal or oblique, not separated into distinct layers. The lateral walls of the middle third are heavier than any other part and have a more distinct separation into

tissue and elastica. The bladder wall above the base has heavy bands of involuntary muscle which run in various planes and which are separated by a fairly loose connective tissue.

**Summary.** The urethrovaginal wall forms a solid compact structure from the external urethral orifice to the base of the bladder. A line of cleavage by areolar tissue between the base of the bladder and the vagina appears at the level of the fornix. The vaginal and rectal walls are separated by a distinct loose areolar avascular zone down to the anoperineal structure where they are tightly fused.

**Specimen V. Six months' infant: (Case 5).** One-half of the specimen is cut sagittally and one-half in cross-section in serial blocks. The *substantia propria* of the vagina is a moderately vascular, compact connective tissue rich in elastica. The muscle is involuntary and arranged in mixed circular and longitudinal fibers. It is most prominent in the lateroposterior portions of the middle third; anteriorly, only scanty circular fibers are seen. The entire wall is fused into a solid structure by dense connective tissue and elastica. No lymphatic tissue is found.

The urethra has a vascular connective tissue *substantia propria* rich in elastica and a well developed circular involuntary muscle. The entire structure is compact with dense connective and elastic tissue. In the portion nearest the bladder there is a distinct heavy muscle bundle surrounding it and the base of the bladder merging superiorly with the bladder musculature. This muscle is better developed in the anterior wall. In this same area, posteriorly, there is relatively more compact connective tissue. In the upper urethra there are a few straight gland-like structures. The bladder wall is composed of heavy involuntary

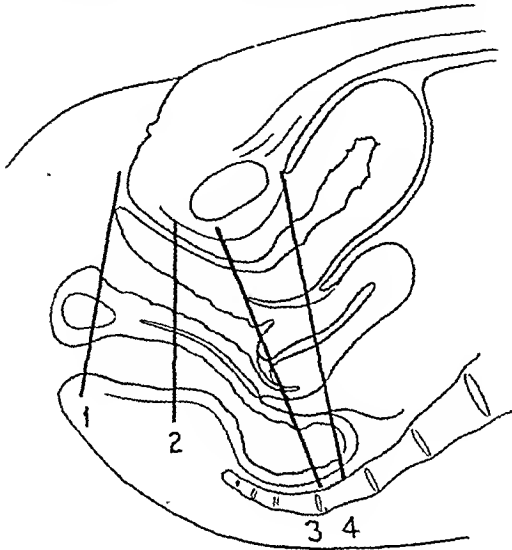


PLATE 1A.

inner circular and outer longitudinal layers. Posteriorly they are heavier than anteriorly. At the upper and lower extremes the muscle almost entirely disappears. The entire wall forms a compact structure fused by a dense connective tissue rich in elastica. No lymphatic tissue is found.

The urethra has a vascular, compact *substantia propria* of connective tissue and elastica and an outer circular involuntary muscle. The entire wall is fused together by dense connective tissue and elastica. There are no glands. At the internal urethral orifice the musculature of the bladder, involuntary in type, consists of heavy bundles woven together by connective

PLATE 1A.

Fig. 1. (Case 3.) Cross section through lower vagina and rectum including apex of perineal body, showing the tight fusion of the anorectal and vaginal wall (hematoxylin and eosin stain  $\times 2.5$ ).

Fig. 1a. (Plate 1B.) A higher power view of the block outlined in Fig. 1 (hematoxylin and eosin stain).

Fig. 2. (Case 3.) A cross section of lower urethra, vagina and rectum, showing a solid urethrovaginal wall and the line of cleavage by areolar tissue between vagina and rectum (hematoxylin and eosin stain  $\times 2.5$ ).

Fig. 3. (Case 3.) Cross section through upper urethra, vagina and rectum, showing the fornices, tip of cervix and cul-de-sac of Douglas. The urethrovaginal wall shows complete integration making one solid structure (hematoxylin and eosin stain  $\times 2.5$ ).

Fig. 3a. (Plate 1B.) A higher power of block outline in Fig. 3 (hematoxylin and eosin stain).

Fig. 4. (Case 3.) Cross section through trigone of bladder, cervix, lower uterine body and rectum. There is a fine line of cleavage between vagina and bladder which shows the urethra on one side just above the urethral mouth. Posteriorly is the cul-de-sac of Douglas (hematoxylin and eosin stain  $\times 2.5$ ).

Fig. 5. (Case 2.) (Plate 1B.) A sagittal section slightly lateral to midline, through bladder, vagina, lower uterus and rectum, showing the line of cleavage anteriorly extending to upper vagina and a line of cleavage posteriorly between vagina and rectum. It also shows fusion of vaginal and urethral wall and both vaginal fornices (hematoxylin and eosin stain  $\times 2.5$ ).



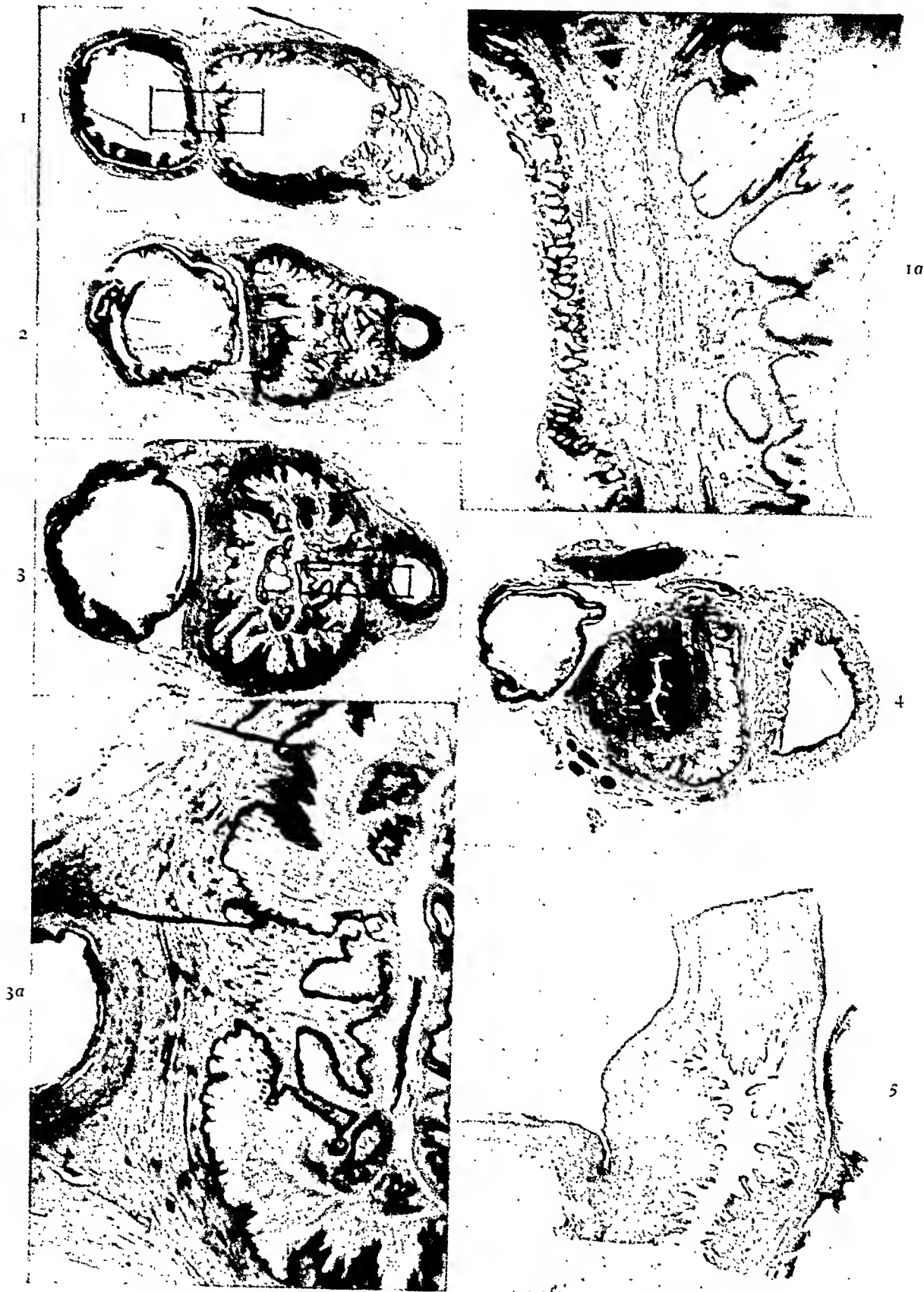


PLATE 1B. Colored microphotographs corresponding to Plate 1A on page 392.



PLATE 2. (Case 5.) A sagittal midline section through bladder, urethra, uterus, vagina, rectum and upper portion of perineal body. Anteriorly the vesico-uterine fold reaches the level of the internal uterine os and an avascular zone of areolar tissue separates the upper vagina from the bladder and urethra. The outer vesical musculature is loosely attached by areolar tissue, looser in texture than that separating the bladder and vagina. Posteriorly the rectum and vagina are separated by an avascular areolar zone down to the tip of the perineal body which fuses vagina and anorectum. The lower rectum is extremely thin and of loose texture and becomes increasingly stout at the higher levels (hematoxylin and eosin stain  $\times 3$ ).

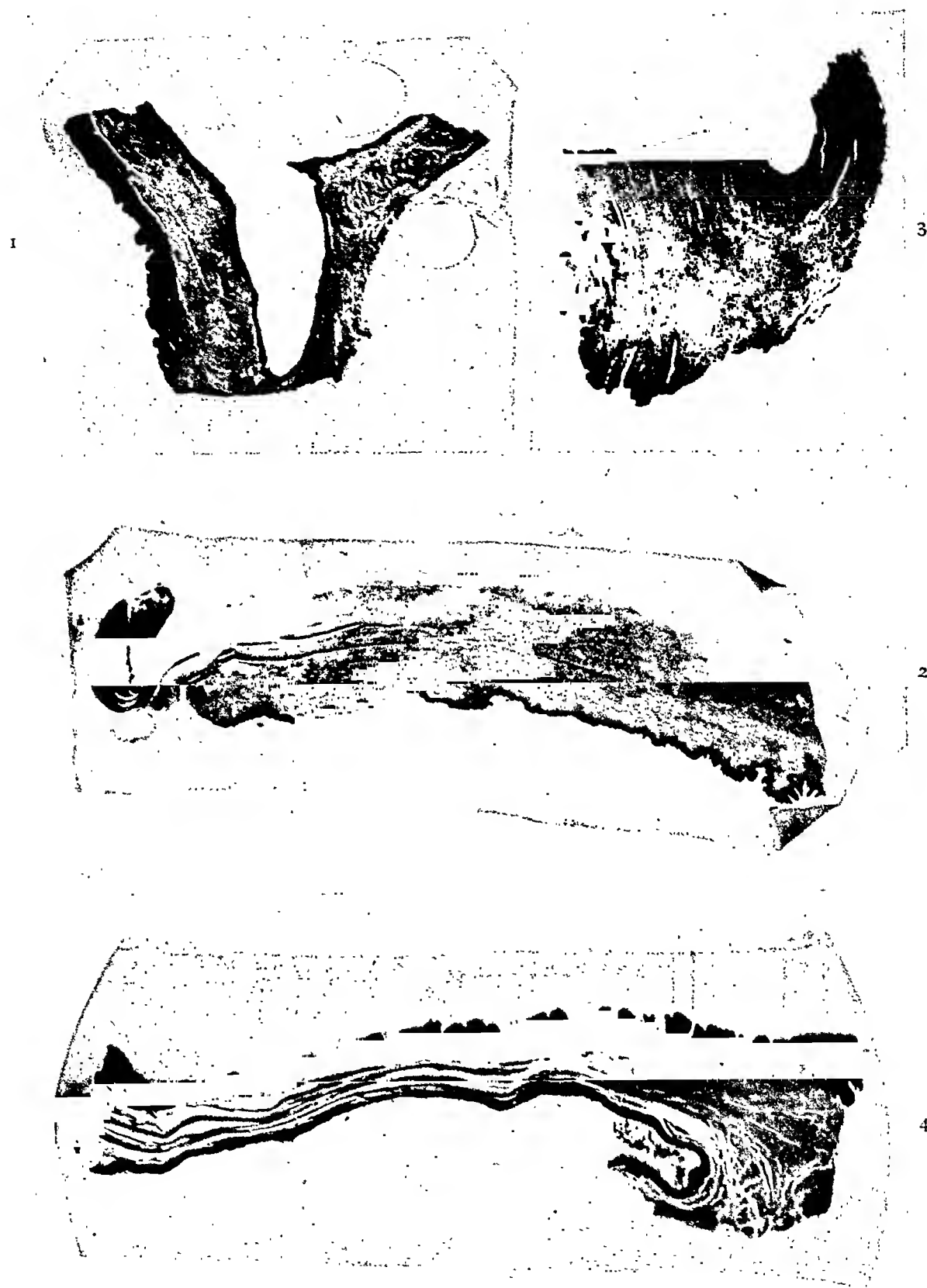


PLATE 3A. Colored microphotographs corresponding to Plate 3B on page 396.

muscle bundles separated by a moderately loose connective tissue.

**Summary.** The urethrovaginal wall is a compact structure from the external urethral meatus to the base of the bladder. At this point, loose areolar tissue begins to separate

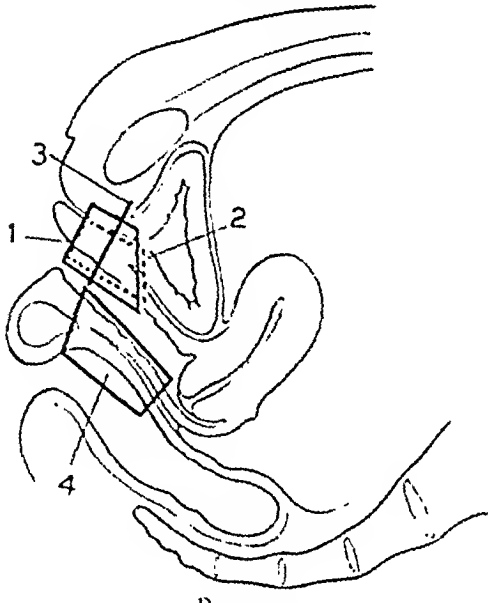


PLATE 3B.

the bladder from the vaginal wall. Posteriorly, the vaginal wall is separated from the rectum by an areolar zone down to the apex of the perineal body. Beyond this point, there is fusion of the wall of the anal canal and the outermost portion of the vaginal wall.

**Specimen VI.** One year infant: (Case 6). The sagittal section includes uterus, cervix, fornices, bladder and urethra. There is an areolar zone extending down from the vesicovaginal fold between the bladder and the upper vagina approximately to the trigone. The bladder wall in this area has large bundles of involuntary muscle lying at different angles separated by a fairly compact connective and elastic tissue.

**Specimen VII.** Nineteen months' infant: (Case 7). The sagittal section includes the rectum, anorectal junction, upper portion of the perineal body, vagina, cervix, fornices,

bladder and upper portion of the urethrovaginal wall. The *substantia propria* of the vagina is moderately vascular, compact, connective tissue rich in elastic fibers. The muscle has a variable arrangement. There is an intermingling of circular and longitudinal fibers so that they cannot be called inner and outer layers. In the anterior wall there are a few longitudinal and a few circular fibers. At the upper and lower ends the muscle is even scantier. The wall is fused into a compact structure by dense connective tissue rich in elastic fibers. No lymphatic tissue is found.

The urethra has a vascular *substantia propria* rich in elastica and circular involuntary muscle fibers. Around the base of the bladder and internal urethral orifice is a heavy involuntary muscle, mainly longitudinal. Anteriorly, it is intimately associated with the inner muscle layers of the bladder. Posteriorly, it is a continuation of the outer longitudinal layer of the bladder wall. The urethra is a compact, solid structure.

**Summary.** The urethrovaginal wall is a compact structure of fibromuscular elastic tissue. There is a line of separation by areolar tissue lying between the vagina at the fornix and the adjacent bladder wall. A loose areolar zone separates the rectum from the vagina down to the apex of the perineal body. Beyond this point, in the anorectal area, there is fusion between vagina and anal canal.

**Specimen VIII.** Twenty years: (Case 8). This patient was three months pregnant and had miscarried about twenty-four hours before death. Specimen consists of (1) sagittal section including bladder, internal urethral orifice, upper urethra, urethrovaginal wall; (2) cross-section through base of bladder and anterior fornix; (3) sagittal section of lower vaginal and rectal walls down to upper portion of perineal body; (4) sagittal section through uterovesical fold.

The *substantia propria* of the vagina is connective tissue moderately vascular, rich in elastic fibers. The muscle coats are distinct and are mainly longitudinal, extending well up toward the fornices. At the level of the fornix

PLATE 3B.

Fig. 1. (Case 8.) A sagittal section through base of bladder, upper urethra and upper vaginal wall, showing a beginning line of cleavage between base of bladder and the tight fusion between the urethrovaginal wall (hematoxylin and eosin stain  $\times 3$ ).

Fig. 2. (Case 10.) A sagittal section through the upper vesico-urethrovaginal wall at a corresponding level to Fig. 1, showing an unusually deep line of cleavage (hematoxylin and eosin stain  $\times 2$ ).

Fig. 3. (Case 8.) A cross section of upper urethrovaginal wall just below the internal urethral orifice, showing the compact fusion (hematoxylin and eosin stain  $\times 3$ ).

Fig. 4. (Case 8.) A sagittal section through the perineal body showing the fusion between lower vagina and anorectal wall and the avascular areolar zone separating the rectum and the vagina. The rectal muscular wall is exceedingly thin (hematoxylin and eosin stain  $\times 3$ ).

there are numerous circular fibers. In the middle third there are some isolated circular muscle bundles. The muscle throughout all areas of the vagina seems distinctly hypertrophied. This hypertrophy may be due to the pregnant state. No lymphatic tissue is found.

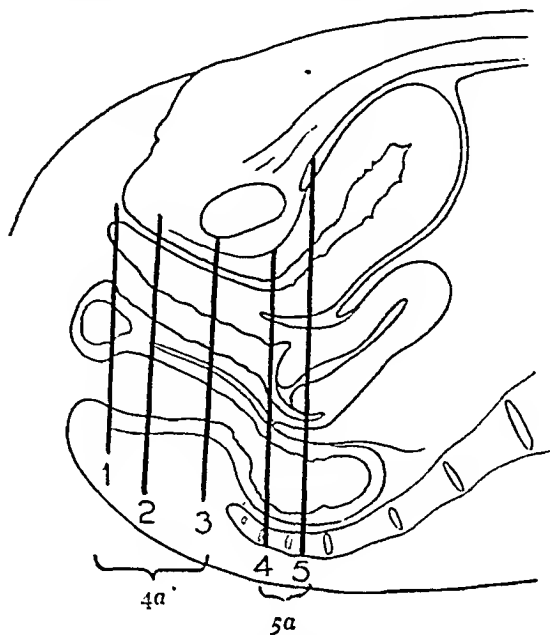
The urethra has a vascular *substantia propria* rich in elastica and a circular, involuntary muscle. The entire structure fuses into a compact tissue. In the upper urethra and the base of the bladder there is a heavy mass of circular bundles of involuntary muscle enclosing the region. Anteriorly it is much heavier in structure than posteriorly, where there is abundant fibrous tissue. No glands are found.

**Summary.** The urethrovaginal wall forms one compact structure with no line of cleavage. The separation between the bladder and the vagina is by loose areolar tissue lying beneath the uterovesical fold, extending down to the base of the bladder. The posterior vaginal wall is separated from the rectal wall by loose areolar tissue extending to the apex of the perineal body. Beyond this point, there is tight fusion between the anal wall and the outermost portion of the vagina.

**Specimen IX. Twenty-four years: (Case 9).** The specimen is cut (1) in serial sagittal sections, including external urethral orifice, urethra, urethrovaginal wall and internal urethral orifice into the base of the bladder; (2) sagittal section of rectovaginal wall including perineal body.

The *substantia propria* of the vagina is compact connective tissue, moderately vascular and rich in elastic fibers. The muscle is involuntary in type and mainly longitudinal with oblique fibers more abundant in the lower one-third of the posterior wall near the perineal

body. In the upper portion near the anterior fornix circular bundles of muscle are abundant and there is some separation in this area into inner circular and outer longitudinal layers. There is no lymphoid tissue. The wall is a compact structure with dense connective tissue and elastic fibers fusing the muscle bundles.



PLATES 4A and 5A.

The urethra has a vascular *substantia propria* and an outer circular involuntary muscle. The musculature is densely fused together by connective tissue with elastic fibers. Near the external orifice are some short tubular glands not found in the upper areas. In the upper portion and at the base of the bladder is a compact circular muscle merging with the bladder wall. It is heavier in the anterior wall; in the posterior, it merges with dense fibro-elastic tissue.

**Summary.** The anterior vaginal wall is densely fused with the urethral wall from the

PLATES 4A and 5A.

Fig. 1. (Case 4.) A cross section of lowermost part of vagina, perineal body and anorectum, showing the tight fusion of vagina and anorectum by the perineal body (hematoxylin and eosin stain  $\times 2$ ).

Fig. 2. (Case 4.) Cross section at a slightly higher level through urethra, vagina and apex of perineal body, showing compact urethrovaginal wall and fusion between vagina and anorectum (hematoxylin and eosin stain  $\times 2$ ).

Fig. 2a. (Plate 4b.) Higher power of urethrovaginal wall blocked out in Fig. 2 (hematoxylin and eosin stain).

Fig. 2b. Higher power of vagino-anorectal wall blocked out in Fig. 2, showing fusion at tip of perineal body (hematoxylin and eosin stain).

Fig. 3. (Case 4.) Cross section through upper urethra, vagina and rectum, showing a solid urethrovaginal wall and a line of cleavage between vagina and rectum, below the eul-de-sac of Douglas (hematoxylin and eosin stain  $\times 2$ ).

Fig. 3a. (Plate 4b.) A higher power view of urethro-vaginal wall blocked out in Fig. 3, showing the tight fusion and almost complete absence of vaginal musculature (hematoxylin and eosin stain).

Fig. 3b. (Plate 4b.) A higher power view of posterior vaginal and rectal walls blocked out in Fig. 3, showing an avascular zone of cleavage (hematoxylin and eosin stain).

Fig. 4. (Case 4.) A cross section through the bladder just above the internal urethral orifice, the vagina and the rectum. There is a beginning line of cleavage between bladder and vagina directly in the midline. Posteriorly, the cleft is the lowermost tip of the eul-de-sac of Douglas (hematoxylin and eosin stain  $\times 4$ ).

Fig. 5. (Case 4.) A cross section at a slightly higher level through bladder, fornices, cervix and rectum. There is a wide separation anteriorly by avascular areolar tissue. Posteriorly is the eul-de-sac (hematoxylin and eosin stain  $\times 4$ ).

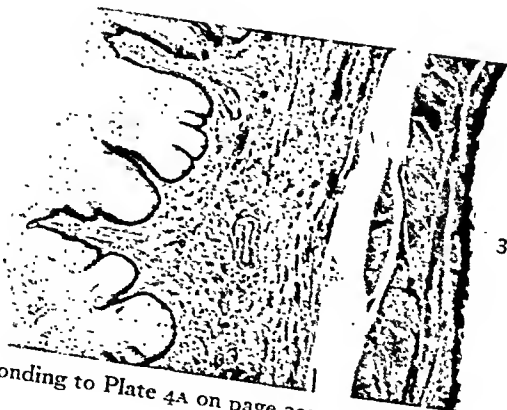
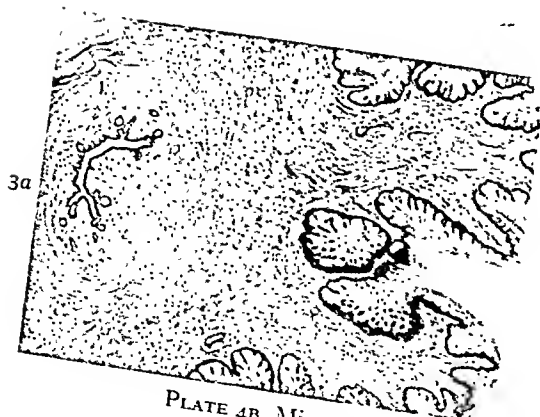
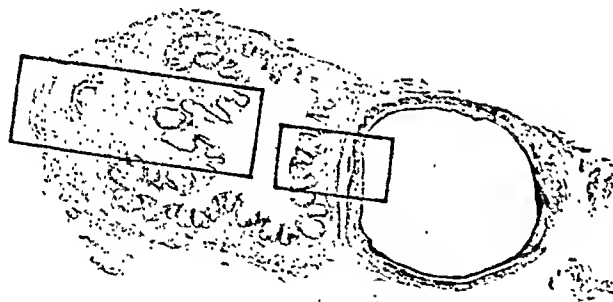
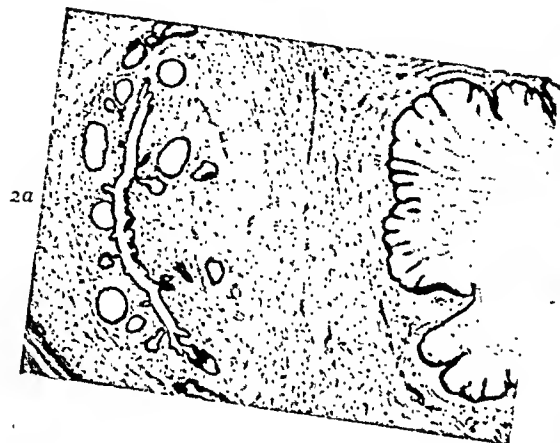
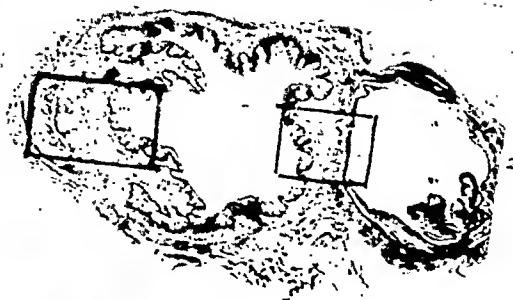


PLATE 4B. Microphotographs corresponding to Plate 4A on page 397.

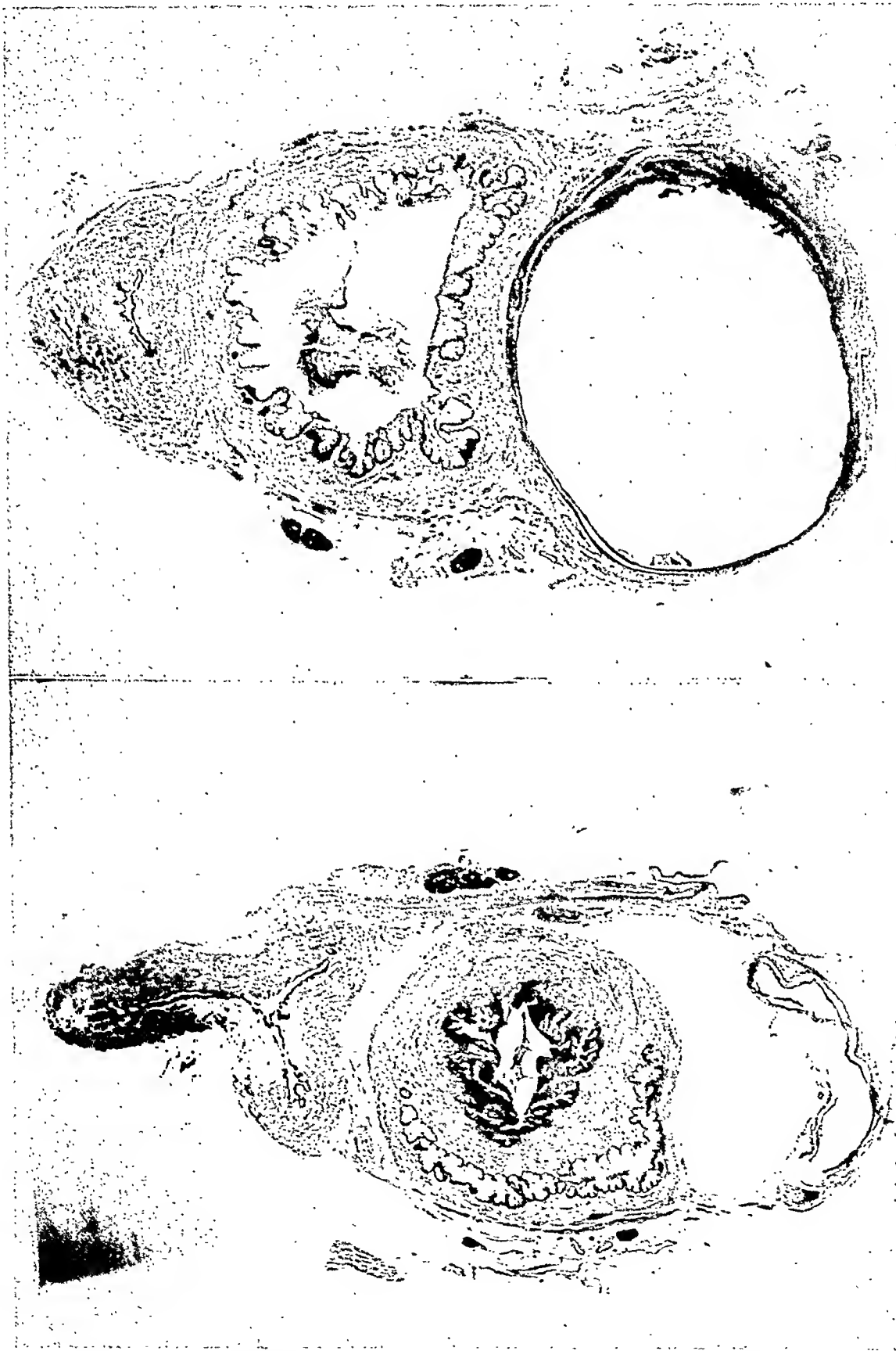


PLATE 5B. Microphotographs corresponding to Plate 5A on page 397.

external urethral orifice to the base of the bladder. At this point, there is a loose areolar zone separating the bladder from the upper vagina and cervix. The posterior vaginal wall and the rectum are separated by loose areolar tissue down to the apex of the perineal body

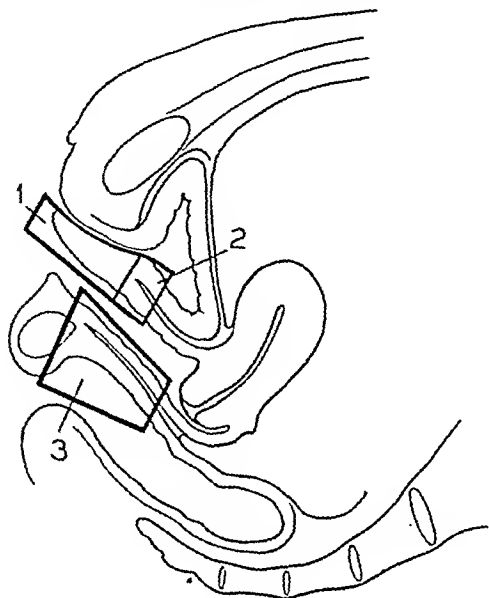


PLATE 6A.

which fuses the outer end of the vaginal and anorectal walls tightly together.

*Specimen X. Twenty-five years: (Case 10).* The specimen is cut (1) in sagittal section lateral to the midline including cervix, vagina and bladder; (2) sagittal section of upper half of urethra and vaginal walls into base of bladder; (3) sagittal section of rectovaginal wall including perineal body. The *substantia propria* of the vagina is a compact connective tissue and rich in elastic fibers. The muscle is involuntary and mainly longitudinal with some oblique fibers lying toward the *substantia propria*. The muscle is heavier in the middle third and becomes scanty at both ends. No lymphatic tissue is found.

The *substantia propria* of the urethra is com-

pact and rich in elastic fibers and vessels. The muscle is involuntary and circular. In the lower one-third are tubular glands; none are found at the upper levels. Extending down from the outer muscle layer of the bladder, is a projection of longitudinal bundles lying parallel to the urethra and extending about one-half of its distance. The muscle in the upper urethra near the internal orifice and the base of the bladder consists of both involuntary and voluntary fibers. The urethral wall is a compact structure, its components held together by dense connective tissue with elastica.

*Summary.* The urethrovaginal wall forms a solid structure from the external urethral meatus to the base of the bladder. From this point to the level of the anterior fornix the walls of the bladder and vagina become separated by loose areolar tissue. The posterior vaginal wall is separated from the rectal wall by a zone of loose areolar tissue down to the apex of the perineal body. Beyond this point, the perineal body fuses both walls tightly together.

*Specimen XI. Thirty-one years: (Case 11).* The specimen is cut (1) in serial sagittal sections including the entire urethra from the external orifice through the internal orifice, and anterior vaginal wall; (2) sagittal sections including bladder, anterior vaginal wall and cervix; (3) sagittal sections including rectovaginal wall and perineal body; (4) cross-section through lateral mid-vagina into paravaginal tissues; (5) parametrium at the level of the cervix.

The *substantia propria* of the vagina is compact connective tissue rich in elastic fibers. The muscle is involuntary. In the mid-anterior wall the muscle fibers are chiefly longitudinal with some oblique fibers. Laterally, the muscle appears somewhat scanty with both longitudinal and circular fibers. Posteriorly, it appears mainly longitudinal with some oblique

PLATE 6A.

Fig. 1. (Case 11.) A longitudinal section of the urethrovaginal wall from base of bladder to the external orifices, showing the tight fusion (hematoxylin and eosin stain  $\times 4$ ).

Fig. 2. (Case 12.) A sagittal section through internal urethral orifice, upper urethra and vagina, showing a line of separation extending down to the upper urethra (hematoxylin and eosin stain  $\times 4$ ).

Fig. 3. (Case 11.) A sagittal section through the perineal body, showing the tight fusion between the wall of the vagina and anal canal musculature; above this is the wall of the vagina and wall of rectum with beginning separation of these two structures (avascular space); (hematoxylin and eosin stain  $\times 2$ ).

Fig. 3a. (Plate 6b.) Higher power through the blocked out area of the perineal body in Fig. 3 on the left (hematoxylin and eosin stain).

Fig. 3b. (Plate 6b.) A higher power through the mid-rectovaginal wall at the area blocked out in Fig. 3 on the right (hematoxylin and eosin stain).



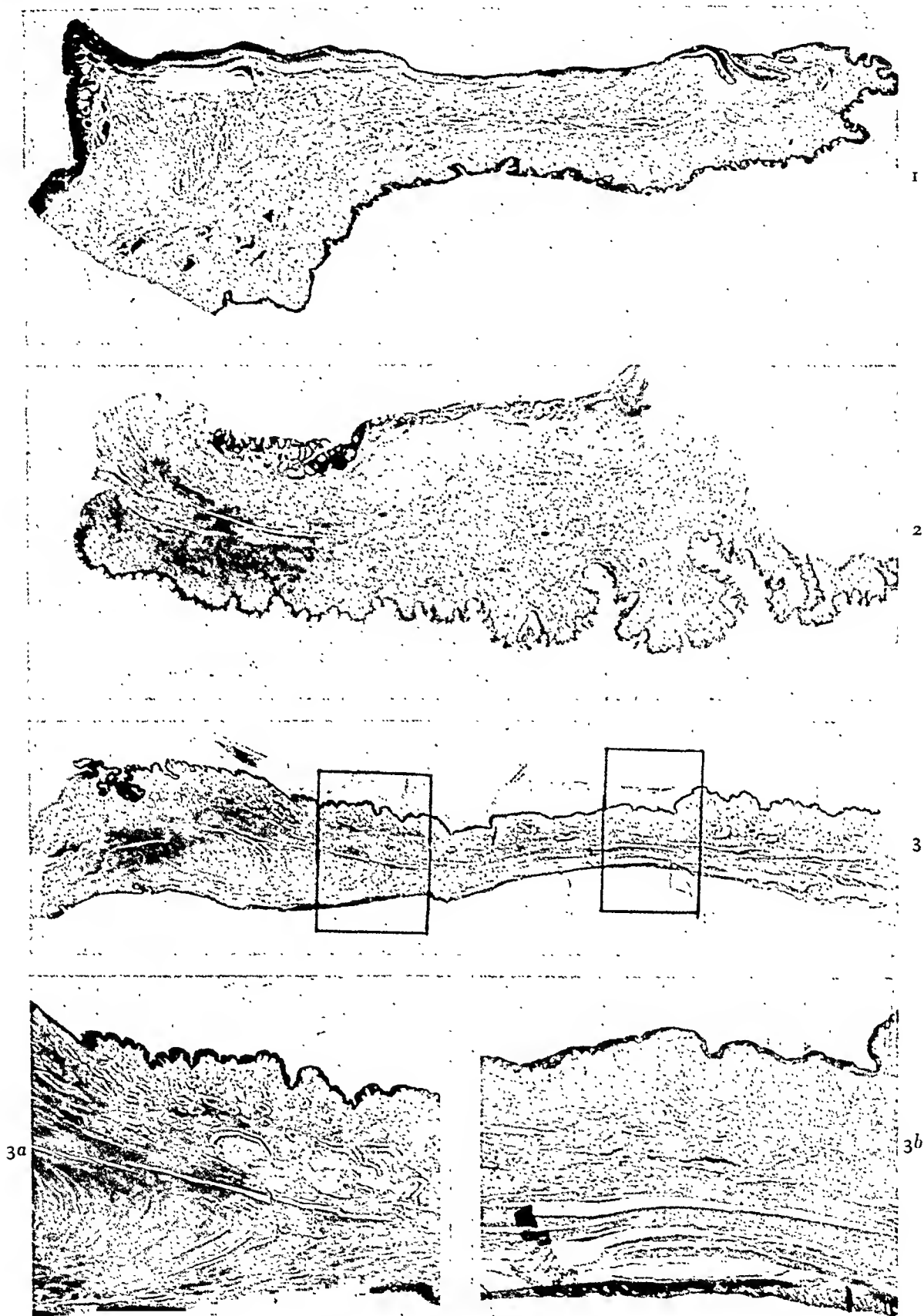


PLATE 6B. Microphotographs corresponding to Plate 6A on page 400.

fibers. In the upper and lower thirds the muscle becomes much less distinct and is lost in the fibro-elastic tissue. There is no definite separation into inner and outer muscle coats. The wall is fused into one dense structure by compact connective tissue rich in elastic fibers. No lymphatic tissue is found.

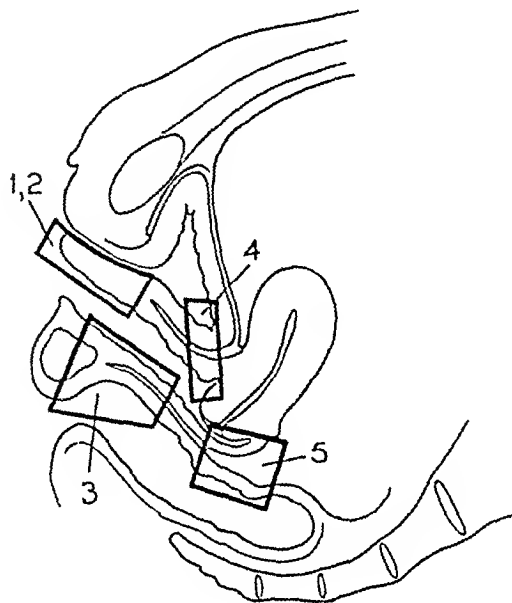


PLATE 7A.

The urethral *substantia propria* is compact connective tissue, vascular and rich in elastic fibers. The muscle is involuntary and mainly circular. Near the external orifice the muscle becomes scantier. At the region of the internal orifice there is a circular group of involuntary muscle bundles which are heavy anteriorly and become interwoven with the bladder muscles. Posteriorly, these bundles enclose the base of the bladder and the upper urethra. Voluntary muscle is not found. The glands are tubulo-alveolar and are found at the external orifice only. The wall forms a compact structure. Its components are held together by compact connective tissue rich in elastic fibers.

**Summary.** The anterior vaginal and urethral walls form one compact structure from the external urethral orifice to the base of the bladder. The bladder and the cervicovaginal region are separated by a loose areolar zone. The posterior vaginal wall is separated from the rectum by loose areolar tissue down to the apex of the perineal body. Beyond this point, the wall of the anal canal and the outermost wall of the vagina are completely fused together.

**Specimen XII. Thirty-four years: (Case 12).** The specimen is cut (1) in sagittal section including urethra, vagina and bladder wall; (2) sagittal section including rectovaginal wall and the perineal body. The vagina has a moderately vascular, compact, connective tissue *substantia propria*, rich in elastica. The upper vaginal wall anteriorly has a compact fibrous layer with very few strands of muscle. Posteriorly above the perineal body, the wall is thicker but similar in nature. There is no lymphatic tissue.

The urethra has a compact, vascular *substantia propria* and involuntary muscle which is mainly circular and oblique. It is separated into muscle bundles by compact connective tissue and elastic fibers. There are a few fibers of voluntary muscle intimately integrated with the involuntary fibers. There are no glands. There is a dense lymphocytic and plasmaeytic infiltration of the bladder wall.

**Summary.** The urethra down to the base of the bladder is tightly fused with the upper vagina. Just above this level there is a separation of the bladder from the vagina by avascular, loose, areolar tissue. The vaginal and rectal walls are separated by loose, areolar tissue. Fusion occurs by means of the perineal body.

**Specimen XIII. Thirty-seven years: (Case 13).** The specimen is cut (1) in cross-section, including the vagina and bladder; (2) sagittal

PLATE 7A.

Fig. 1. (Case 18.) A sagittal section through the urethrovaginal wall to the external orifices of the urethra and vagina showing its compact structure (hematoxylin and eosin stain  $\times 2.5$ ).

Fig. 2 is the same as Fig. 1, showing the rich elastic component (Verhoeff stain  $\times 2.5$ ).

Fig. 3. (Case 16.) A sagittal section through the perineal body, showing the tight fusion of vaginal and anal canal musculature; below is the thin wall rectum and the separation between it and the vagina, and the rich elastica (Verhoeff stain  $\times 2$ ).

Fig. 4. (Case 14.) A sagittal section through the anterior fornix and bladder, showing the avascular areolar zone of separation between bladder and upper vagina. The bladder wall is of very loose texture (hematoxylin and eosin stain  $\times 3$ ).

Fig. 5. (Case 16.) A sagittal section through the posterior fornix and rectum showing the cul-de-sac peritoneal fold reflected from cervix tip of vaginal wall on to the rectum. Between the upper vaginal wall and rectum is a wide area of separation (avascular space). The vaginal and cervical walls are fibrous with scanty elastic (Verhoeff stain  $\times 2$ ).

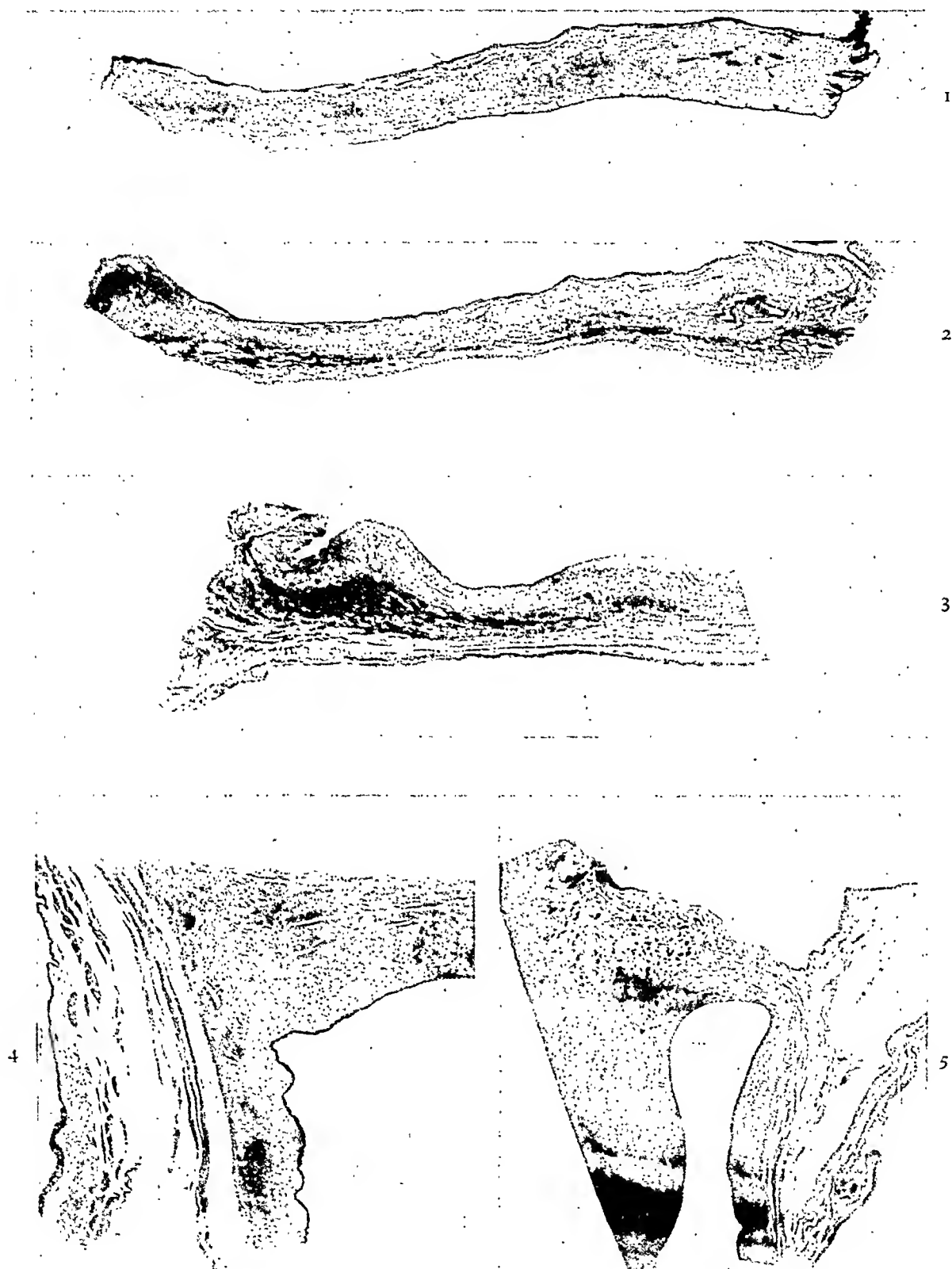


PLATE 7B. Microphotographs corresponding to Plate 7A on page 402.

section, including the vagina and rectum. The vagina has a vascular, compact *substantia propria* rich in elastic fibers and an outer wall of dense connective tissue with elastic fibers carrying numerous large arteries and veins. It is fused into one solid structure. The pos-

tissue down to the apex of the perineal body. At this point, the vaginal wall and the anal wall become tightly fused.

*Specimen XIV. Forty-one years: (Case 14).* The specimen is cut (1) in sagittal section including cervix, anterior fornix and bladder; (2) sagittal section including cervix, posterior fornix, cul-de-sac and rectum. The vaginal wall has a vascular, compact *substantia propria* and externally scanty involuntary muscle, mainly longitudinal and intermingled with some oblique and a few circular bundles at the level of the bladder wall. Above the trigone the muscle becomes lost in a dense fibrous tissue in the cervical region. The vaginal wall of the posterior fornix is similar in structure.

The posterior wall of the bladder above the trigone has a moderately compact *substantia propria*. The muscular wall consists of bundles in various planes. The innermost are composed of small, rather circular and oblique bundles lying in a fairly compact fibro-elastic tissue. More externally, the bundles are in widely separated layers lying in extremely loose areolar tissue with abundant elastic fibers. The bladder wall in this area is extremely loose and areolar tissue widely separates its muscular fibers more so than it separates the two organs.

*Summary.* The bladder is separated from the cervicovaginal wall by a loose, thin, avascular areolar tissue. The vagina is separated from the rectum by a wide zone of loose areolar tissue. Somewhat lateral to the midline it carries a few heavy walled vessels.

*Specimen XV. Forty-two years: (Case 15).* The specimen is cut (1) in sagittal section including urethra, urethrovaginal wall and base of bladder; (2) sagittal section including cervix, bladder and rectum.

The vagina has a compact fibro-elastic *substantia propria*. The muscle is moderately well

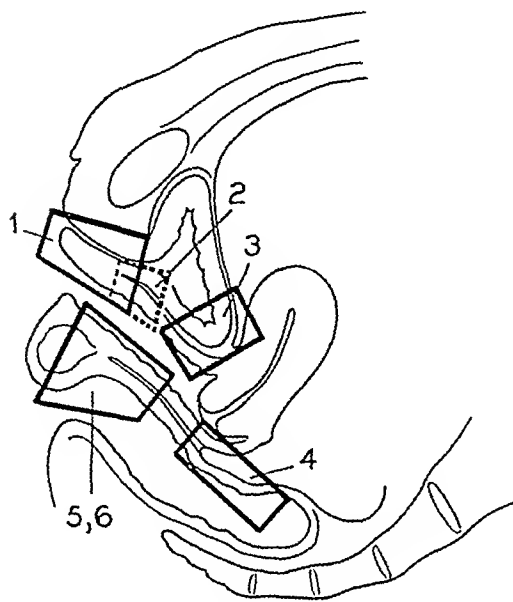


PLATE 8A.

terior inferior vaginal wall has a vascular, compact *substantia propria* with abundant elastic fibers and an outer compact, connective tissue carrying large veins and arteries. Muscular tissue is extremely scanty.

The bladder at the base has abundant involuntary muscle separated into bundles by wide fibro-elastic tissue. Voluntary fibers are not found. Beneath the epithelium is a fairly dense mixed cell inflammatory reaction.

*Summary.* The vagina and the base of the bladder are tightly fused by dense fibrous tissue. The inferior posterior vaginal wall is separated from the rectum by a loose avascular

PLATE 8A.

Fig. 1. (Case 22.) A sagittal section through the vesico-urethrovaginal wall showing a compact structure and a line of cleavage between base of bladder and upper vagina (hematoxylin and eosin stain  $\times 2$ ).

Fig. 2. A sagittal section through base of bladder and upper urethra and upper vaginal wall, showing the rich elastica and line of cleavage (Verhoeff stain  $\times 2$ ).

Fig. 3. (Case 19.) A sagittal section through bladder, uterovesical fold and anterior fornix lateral to the midline, showing the narrow avascular areolar zone separating bladder and vagina (Verhoeff stain  $\times 2$ ).

Fig. 4. (Case 19.) A sagittal section through the cul-de-sac of Douglas, the posterior fornix and the rectum, showing the loose avascular areolar zone separating vagina and rectum in the cul-de-sac area (Verhoeff stain  $\times 2$ ).

Fig. 5. (Case 19.) A sagittal section through the perineal body, showing a high point of fusion with the rectum and a low point of fusion with the vagina, an unusual variation; the perineal body is rich in elastica (Verhoeff stain  $\times 2$ ).

Fig. 6. (Case 22.) A sagittal section through the perineal body, showing the tight fusion between the vagina and anorectal musculature (hematoxylin and eosin stain  $\times 1.5$ ).



PLATE 8a. Microphotographs corresponding to Plate 8a on page 404.

developed and consists of a network of longitudinal and oblique fibers. Near the fornices the muscular elements become lost in a dense fibro-elastic tissue. The wall of the vagina is fused into a compact structure by dense connective tissue and elastic fibers and is poorly vascularized. There is no lymphatic tissue.

The urethra has a poorly vascular fibro-elastic *substantia propria* and a circular layer of involuntary muscle. There is a stout group of circular bundles of involuntary muscle enclosing the upper urethra and the base of the bladder. The bundles are larger on the anterior wall and somewhat smaller on the posterior wall. They are firmly bound together by fibro-elastic tissue and merge with the muscular coats of the bladder.

**Summary.** The urethrovaginal wall is fused into a solid structure by dense connective tissue and elastic fibers. There is an avascular, areolar zone separating the bladder wall from the cervicovaginal wall. The rectum is separated from the cervicovaginal wall by a loose areolar zone.

**Specimen XVI. Forty-two years: (Case 16).** The specimen is cut (1) in sagittal serial section, including entire urethra, base of bladder and urethrovaginal wall; (2) sagittal serial section, including anterior vaginal wall, anterior fornix, cervix and bladder; (3) sagittal section of perineal body including the lower half of the vagina; (4) sagittal section of cervix, posterior fornix, posterior vaginal wall, cul-de-sac and anterior rectal wall.

The vagina has a compact *substantia propria* with abundant dense connective tissue and elastica and a few moderately large vessels. In the outer portion there are some strands of muscle fibers without a definite pattern consisting of longitudinal, oblique and circular fibers held together by compact fibro-elastic tissue. At the fornices the muscle becomes even scantier where it is lost in the compact fibro-elastic wall of the cervix.

The urethra has a compact *substantia propria* and circular involuntary muscle bundles, all held in a compact fibro-elastic tissue. At the base of the bladder there is a mass of stout circular involuntary muscle bundles surrounding the base of the bladder and upper urethra. It is somewhat heavier anteriorly than posteriorly. It forms the muscular coat of the floor of the bladder. On the posterior wall there is a muscle sheet which continues down from the outer layer of bladder muscle with fibers run-

ning parallel to the floor of the bladder and extending down to the upper urethra outside of the circular muscle. There are tubulo-alveolar glands at the mouth in the anterior and posterior walls.

**Summary.** The urethrovaginal wall is one compact structure woven together by dense connective tissue and elastic fibers from the meatus to the base of the bladder. There is a loose areolar avascular zone separating the bladder from the cervicovaginal wall down to the base of the bladder. The posterior vaginal wall and the rectum are separated by a loose avascular areolar zone down to the apex of the perineal body. Beyond this point, the wall of the anal canal fuses with the wall of the vagina.

**Specimen XVII. Forty-three years: (Case 17).** The specimen is cut (1) in cross-section of the mid-urethra including the urethrovaginal wall; (2) sagittal section of the upper urethrovaginal wall, base of bladder, upper vaginal wall, uterovesical fold and cervix; (3) cross-section of upper vaginal and rectal walls just below Pouch of Douglas; (4) cross-section immediately above number (3) and including the pouch of Douglas.

The vagina has a moderately vascular *substantia propria* rich in elastic fibers. The muscle fibers, involuntary in type, are mainly oblique and longitudinal. They are woven together by a dense connective tissue and elastica. At the mid-vagina the muscle fibers of the lateral walls are heavier than they are anteriorly or posteriorly. The wall is formed into a compact structure by dense connective tissue and abundant elastica. In the upper portions near the fornices, the muscle becomes scanty. No lymphatic tissue is present.

The *substantia propria* of the urethra is compact and rich in elastic fibers. Circular involuntary muscle fibers completely enclose the urethra. The entire wall is woven together firmly by dense connective tissue and elastic fibers.

**Summary.** The urethrovaginal wall forms one compact structure interwoven by connective tissue and elastic fibers. There is a loose, avascular, areolar zone separating the bladder from the anterior fornix down into the base of the bladder. The vaginal and rectal walls are separated by a loose, avascular, areolar zone.

**Specimen XVIII. Forty-seven years: (Case 18).** The specimen is cut (1) in serial sagittal

sections of entire urethra up to and including internal urethral orifice; (2) sagittal section of perineal body and lower vagina; (3) cross-section of base of bladder, vaginal wall and cervix. The vagina has a compact *substantia propria* rich in elastic fibers with some bundles of involuntary muscle not arranged in a definite pattern but which are partly longitudinal and partly oblique or circular. The muscle of the mid-portion is slightly more prominent than at either end where it becomes lost in fibro-elastic tissue. The wall is formed into one compact structure by a network of dense connective tissue rich in elastic fibers. No lymphatic tissue is found.

The urethra has a *substantia propria* rich in elastic fibers and circular bundles of involuntary muscle. At the vesical neck there is a distinct group of circular involuntary muscle which encloses the base of the bladder and the upper one-third of the urethra. It is heavier on the anterior wall. There are tubulo-alveolar glands in the lower one-third of the urethra in the urethrovaginal wall. The urethra forms a compact structure by interweaving of all layers with connective tissue and elastic fibers.

*Summary.* The urethrovaginal wall is one completely fused structure bound together by dense connective tissue and elastic fibers from the meatus to the base of the bladder. There is a loose, avascular, areolar zone separating the bladder wall from the cervicovaginal wall. Posteriorly, there is a loose, avascular, areolar zone separating the vagina from the rectal wall down to the apex of the perineal body. Beyond this point, the wall of the anal canal is completely fused with the vagina.

*Specimen XIX.* Sixty years: (Case 19). The specimen is cut sagittally in serial blocks, including (1) vaginal wall into the base of the bladder; (2) vesico-uterine fold, bladder and anterior vaginal wall; (3) lower vaginal and rectal walls and perineal body; (4) cervix, posterior fornix, pouch of Douglas and rectal wall.

The vagina has a *substantia propria* with abundant elastic fibers and externally a very scanty amount of involuntary muscle buried in fibro-elastic tissue. The muscle strands are small and mainly longitudinal. They are scanty at upper and lower ends where they become lost in fibro-elastic tissue. The vaginal wall forms one compact structure. No lymphatic tissue is found.

The urethra has a fibro-elastic *substantia*

*propria* and a circular involuntary muscle. Glands are not found. There is a mass of circular involuntary muscle fibers enclosing the upper urethra and the neck of the bladder, about as heavy anteriorly as posteriorly. Posteriorly, there is also a prolongation of the outer longitudinal vesical muscle into the external surfaces of the circular mass.

*Summary.* Beneath the vesicocervical fold is a narrow avascular areolar tissue which separates the bladder from the upper vagina approximately to the level of the internal urethral orifice. The vagina and rectum are separated by a loose avascular zone down to the apex of the perineal body, where tight fusion occurs between perineal body and rectum. Anteriorly the areolar zone extends a greater distance before fusion finally occurs.

*Specimen XX.* Sixty-two years: (Case 20). This specimen consists of serial cross-sections of the urethrovaginal wall. No glands were seen in the vagina and urethra. The *substantia propria* of the urethra is compact and rich in elastica; the muscle bundles are circular. The entire wall is fused to the anterior vaginal wall by a compact weaving of dense connective and elastic tissue.

*Specimen XXI.* Sixty-seven years: (Case 21). This specimen was cut in serial sagittal sections of (1) upper urethra, vagina and internal urethral orifice; (2) base of bladder and vagina; (3) anterior fornix and cervix. The vagina has *substantia propria* rich in elastica and some involuntary muscle bundles. The muscle runs mainly longitudinally, but is interspersed with oblique and circular bands. The circular bands are small in size. Superiorly in the anterior wall the muscle extends well up towards the anterior fornix, where it becomes lost in a dense fibro-elastic structure at the cervicovaginal junction. In the posterior fornix the wall is densely fibrous with abundant elastic fibers and is devoid of muscle. The entire wall is tightly bound together into one solid structure by interlacing bands of connective tissue rich in elastic fibers. The vesicovaginal fold reaches the level of the anterior fornix. No lymphatic tissue is found.

The urethra has a compact *substantia propria*. At the vesical neck there are circular bundles of involuntary muscle which surround the floor of the bladder and upper urethra. This muscle is prominent on the anterior wall but becomes much scantier in the posterior wall where it is interwoven with dense fibro-elastic

tissue. Interspersed with the circular muscle in this region are some longitudinal fibers. No voluntary muscle fibers are seen.

*Summary.* The urethrovaginal wall forms one compact structure interwoven by dense fibrous bands of connective tissue and elastic fibers. There is a loose avascular areolar zone separating the bladder from the vagina down to the base of the bladder.

*Specimen XXII. Seventy-two years: (Case 22).* The specimen is cut (1) in serial sagittal sections of urethra, vagina and base of bladder; (2) sagittal section of perineal body. The vagina has a *substantia propria* with abundant elastic fibers and scanty involuntary muscle. The muscle fibers run mainly longitudinally. Inferiorly, they become lost in the perineal body. The vaginal wall forms one compact structure. No lymphoid tissue is found. The urethra has a fibro-elastic *substantia propria*. The muscle is involuntary in type and consists of circular bundles bound together by dense connective tissue and elastic fibers. At the internal urethral mouth is a mass of circular bundles of involuntary muscle enclosing the upper urethra and the floor of the bladder, stouter in the anterior wall than in the posterior. No voluntary fibers are seen.

*Summary.* There is a tight fusion between the urethra and the anterior vaginal wall through the entire length of the urethra up to the trigone of the bladder. Slightly above the level of the internal urethral orifice there is a narrow zone of areolar tissue separating the base of the bladder from the upper vagina. The perineal body fuses the anal and vaginal walls. There is a narrow areolar zone lying between the rectum and the vagina from the peritoneal reflection to the apex of the perineal body.

#### RÉSUMÉ OF MICROSCOPY

The vaginal wall is a compact fibro-muscular-elastic structure. The muscular component has a consistently uniform pattern with a few variations at certain age periods. The fibers are chiefly longitudinal, interspersed with a variable number of circular and oblique fibers; but they do not form distinct muscular coats. They are most abundant in the middle third of the organ and are most prominent in the posterior and lateral portions. Anteriorly, they become lost in the urethrovaginal wall. In the

fetus and infant there is a distinct, narrow, circular muscle at the level of the fornices; in the adults this is absent, except during pregnancy, when the entire musculature undergoes hypertrophy. In the non-pregnant adult organ, the muscular component at the introitus and fornices is scanty and lost in the fibro-elastic wall. In old age the muscle becomes atrophic and the vaginal wall is mainly a fibro-elastic structure.

The anterior vaginal wall is tightly fused with the urethra from the base of the trigone to the external urethral orifice. It forms a compact urethrovaginal wall completely integrated into one solid structure by interweaving connective tissue and elastica. Interweaving is so intimate that it is difficult to distinguish the muscular component of the vagina from that of the urethra. The upper urethra and the trigonal area of the bladder are surrounded by a muscular coat of variable arrangement. The trigonal area of the bladder and upper vagina still remain tightly fused. The cleavage plane between bladder and vagina is packed with loose areolar tissue. The lowermost point of the vesico-uterine fold usually reaches the level of a plane passed between the interureteral ridge and upper vagina at the fornix. Rarely, it extends beneath the trigone as far as the internal urethral orifice.

The vagina has a less complex relationship to its surrounding organs posteriorly than anteriorly. A line of cleavage between vagina and rectum by loose avascular areolar tissue extends from the pouch of Douglas to the apex of the perineal body. The perineal body tightly fuses the vaginal wall to the muscular coats of the lowermost rectum and anus. Very occasionally, the separation is uneven and extends further down on the vaginal side than on the rectal side. The anorectal mucosa is attached loosely to its submucosa. It is worthy of note that the rectum has an extremely thin muscular wall of very loose texture. Its muscular "coat" becomes much "stouter" as it approaches the rectosigmoid junction.



## CONCLUSIONS

Specimens consisting of the perineal body, anal canal, rectum, vagina, urethra, bladder, cervix and fundus were removed *en masse* from twenty-two cadavers: four fetus, three infants and fifteen adults. After fixation, some of these specimens were subjected to serial cross-sections, some to serial sagittal sections and others to both, following an accurate longitudinal bisection. The purpose of the investigation has been to demonstrate microscopically all the tissues between the mucosa of the vagina throughout its entire length and the mucosa of all the juxtaposed organs such as the anal canal, the rectum, the urethra and the bladder. Further, this investigation has as its purpose to prove or disprove the presence of a *fascia* variously designated, isolated and utilized for reconstruction of the relaxed, sagging and sacculating anterior and posterior vaginal walls. As a basis for discussion and classification of tissues, a *fascia* is considered a sheet of compact connective tissue of variable thickness, completely devoid of muscle substance and possessing tensile strength for supportive and reconstructive purposes.

1. There is a complete fusion of the fibro-muscular-elastic wall of the vagina and the juxtaposed wall of the urethra throughout its entire length, from the external urethral orifice to the trigone of the bladder. These two walls are closely integrated by interweaving strands of collagenous connective tissue and elastic fibers. No line of separation is present. But the portion closer to the urethral canal is more vascular than the portion closer to the vaginal canal. Between the urethra and the vagina there is neither cleavage plane, areolar zone, nor any substance remotely resembling a sheet-like structure of compact connective tissue, i.e., a *fascia*.

2. There is a definite line of separation, a cleavage plane, an areolar zone between the anterior vaginal wall and the juxtaposed wall of the bladder from the vesico-uterine fold to the trigone. This line of separation is marked by the presence of

loose shreds of areolar fibers. There is no substance between the bladder and the anterior vaginal wall which in any way resembles a sheet-like structure of compact connective tissue, i.e., a *fascia*.

3. There is a complete fusion of the fibro-muscular-elastic structure of the outermost vaginal wall as it comes in contact with the short perineo-anal canal. The point of fusion ends approximately where the anal canal continues as the rectum. Between this portion of the vagina and the perineo-anal canal there is no cleavage plane, no areolar zone, no substance which in any way resembles a sheet-like structure of compact connective tissue, i.e., a *fascia*.

4. There is a definite line of separation, a cleavage plane, an areolar zone between the posterior vaginal wall and the juxtaposed rectal wall, beginning approximately at the anorectal junction, ending where the rectum comes in contact with the cul-de-sac peritoneal reflection. The separation of these two organs is marked by the presence of loose shreds of areolar fibers. Between the posterior vaginal wall and the rectum, there is no substance which in any way resembles a sheet-like structure of compact connective tissue, i.e., a *fascia*.

5. The vaginal wall is a fibro-elastic muscular structure with abundant connective tissue fibers. The muscular fibers are not separated into two distinct layers of inner circular and outer longitudinal, but consist of circular and longitudinal fibers of irregular distribution. It is only in the mid-portion of the vagina that the circular fibers give a suggestive pattern of a definite arrangement. In the same location both circular and longitudinal fibers are "stouter," particularly in the lateral and posterior portions. These muscle fibers become lost in that portion of the vaginal wall forming the fornices and the cervix. Inferiorly, they also become lost around the introitus of the vagina and perineal body. The vascular components of the vaginal wall are abundant in the mid-portion and in the lateral portions of the vagina.

6. The mucosa of the anorectum is loosely attached by its submucosa; the

muscles at the anorectal junction are intimately integrated into the perineal body. Above the perineal body the inner and outer muscular layer of the rectum are separated by an areolar tissue as loose in texture as the submucosa and as the areolar zone lying between the rectum and vagina. The muscularis of the rectum is extremely thin, becoming increasingly stout and compact as the rectosigmoid is reached.

7. The absence of an areolar cleavage plane between the anterior vaginal wall and the wall of the urethra, and the presence of a complete fusion of the fibro-muscular-elastic structure of these two organs, necessitates blunt dissection of the fibro-muscular-elastic structure to effect a separation between the urethra and the vagina. Separation of the fused layers of tissue of these two organs invariably leads to a manageable but unavoidable general ooze.

8. The presence of a definite line of separation, an avascular, areolar cleavage plane between the fibro-muscular-elastic vaginal wall and the bladder wall facilitates a clean cut anatomic and bloodless separation of these two organs if the operator enters the true avascular vesicovaginal space.

9. The absence of an areolar cleavage plane between the outermost portion of the posterior vaginal wall and the perineo-anal canal and the presence of a complete fusion of these structures, necessitates blunt dissection to effect a separation of this portion of the vagina. Separation of the fused layers of tissue of these organs leads to manageable but unavoidable general ooze and even brisk bleeding.

10. The presence of a definite line of separation, an avascular areolar cleavage plane between the posterior vaginal wall and the rectal wall, beginning approximately at the anorectal junction, ending where the vaginal wall fuses with the cervix and the rectum comes in contact with the cul-de-sac peritoneal reflections, facilitates a clean cut anatomic and bloodless separation of the rectum and the vagina,

provided the operator enters the true avascular rectovaginal space.

11. There is no microscopic evidence whatsoever to substantiate belief in the existence of a so-called "fascia" between the urethra and the vagina, between the bladder and the vagina, between the perineo-anal canal and the vagina and between the rectum and the vagina, predicated on the basic concept that a fascia is a connective tissue sheet of variable thickness and possessing tensile strength. Such designations as urethrovaginal, vesicovaginal, pubocervical, pubovesicocervical, uteropubic, rectovaginal fascias are gynecological misconceptions. And to dismiss the argument merely on the basis of a variation in terminology is a *reductio ad absurdum*. The gynecologist who "succeeds" in isolating these "indispensable fascias" for reconstructive purposes has split the fibro-muscular-elastic vaginal wall into two layers, the innermost of which he erroneously designates as a fascia. Since the microscopy of the areas in question shows none of the above mentioned fascias, these designations should be stricken from the literature dealing with *gynecological* anatomy of the pelvis and that dealing with reconstructive vaginal plastic surgery.

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# CURARE—CYCLOPROPANE ANESTHESIA

## CLINICAL OBSERVATIONS IN THREE HUNDRED FIFTY CASES

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OUR purpose in this paper is to add our experiences to those of others before us in the use of curare\* as a relaxing agent in cyclopropane anesthesia for major surgery. It is standardized so that each cubic centimeter contains 20 units of the standard drug.

TABLE I  
OPERATIONS

Hysterectomy.....	42
Appendectomy.....	44
Pelvic laparotomy.....	36
Gastric resection.....	6
Cholecystectomy.....	19
Ureterotomy.....	1
Bowel resection.....	2

The types of patients selected for curare administration were those who, in our experience, usually are difficult to relax with cyclopropane alone. All upper abdominal patients were given curare unless the patient was very thin with poor tone to the muscles. Many lower abdominal cases were given curare, especially the husky muscular type of individual. Knowing our surgeons as we do, we know those who require flaccid relaxation and who are content with less than this. Anticipating these requirements in each instance we used the drug according to the needs of the surgeon. In all of the patients there was a deliberate effort to maintain a lighter level of anesthesia and obtain relaxation by the use of curare rather than by a deep level of anesthesia. In most of the subjects induction was obtained with pentothal sodium (0.2 Gm. or less), immediately followed by cyclopropane and the patient carried to the

second plane of the third stage. The administration of curare was withheld until the surgeon was ready to make the skin incision at which time 40 to 60 units of the drug were administered intravenously. If there was any doubt about the curare being necessary for relaxation it was withheld

TABLE II  
DOSAGE  
(Units or Milligrams)

40 units.....	27
50.....	45
60.....	51
70.....	8
80.....	6
90.....	4
100.....	9

TABLE III  
AGES IN YEARS

0-10.....	0
10-20.....	19
20-30.....	47
30-40.....	46
40-50.....	27
50-60.....	9
60-70.....	1
70-80.....	1

until the peritoneum was opened, then if relaxation was not what the surgeon desired the curare was administered at that time. No effort was made to give the solution slowly, for it was found after the first twenty-five or thirty patients that this was not necessary. In most subjects the initial dose produced spectacular abdominal relaxation within two to four minutes. In eleven instances, however, this effect was delayed and an additional 20 to 40 units were given after waiting about five or six minutes for adequate relaxation. Thirty-seven patients required supplemental intravenous administration of curare toward the close of the operation so that the peritoneum could be approximated with

\* The preparation of curare used was manufactured by E. R. Squibb & Sons Co. and goes under the trade name Intocostrin.

ease. (Tables II and V.) Usually 20 to 40 units as a single injection were sufficient to give adequate relaxation for closure of the peritoneum and fascia without strain or tension upon the tissues. In nine instances (Table II) the total dosage of curare ex-

TABLE IV  
RELAXATION

Good.....	140
Fair.....	5
Poor.....	5

TABLE V  
DURATION OF ANESTHESIA

Less than 30 minutes.....	3
30-45 minutes.....	15
45-60.....	27
60-75.....	31
75-90.....	27
90-120.....	25
Over 120.....	22

ceeded 100 mg. but the average patient required less than the 100 units. The ages (Table III) of this group were from ten to eighty years with the majority falling between twenty and forty years of age. Good relaxation (Table IV) was obtained in one hundred forty of the patients. Spinal-like relaxation occurred in some but these are included under the classification "good."

#### PHYSIOLOGICAL EFFECTS

**Respiration.** There was no change in the respiration in most of our patients providing the initial dose was not too great. In six subjects, in which we afterward felt we had exceeded slightly the requirements of the initial dose, there was a noticeable alteration of the respiratory exchange characterized by jerky expiration followed by a decreased respiratory amplitude. The effect on the rate was variable. Intubation was not performed routinely except in upper abdominal patients and then the intubation was delayed until after curare had been administered. Curare definitely aids in intubation by relieving the tendency toward laryngospasm and by relaxing the jaw muscles.

**Circulation.** With cyclopropane administration there are occasionally premature cardiac contractions or even an absolute

irregularity but this can usually be relieved by the introduction of a very small amount of ether. If ether in any amount has been introduced into the system before the curare has been given, it is best to reduce the estimated dose of curare. If adequate relaxation is not obtained, a second injection will not delay the surgeon long and may save the anesthetist an embarrassing moment of apnea for the patient. The peripheral circulation indicated by capillary refill time as described by Guedel was found to be normal. A slowing of capillary refill time occurred in three patients. In these, however, there was considerable blood loss and it is questionable whether the delayed capillary refill time was due to anything other than the low blood volume.

In two instances we believe that curare did produce a mild hypotension for a short period, for the blood pressure fell before any marked blood loss or any visceral traction by the surgeon. In neither case was any stimulation required nor any ill effects noted.

**Gastrointestinal Tract.** Under curare and cyclopropane anesthesia there is a definite decrease in the intestinal motility and usually some contraction but it does not approximate the contraction as seen in spinal anesthesia. It is very common, however, to notice the spectacular change which takes place after the administration of curare in a patient who is pushing distended intestines out into the wound. In a matter of thirty seconds to two minutes the bowel contracts to a point where it does not protrude into the incision at all and surgery can be carried on with the greatest of ease.

#### COMPLICATIONS

There were no deaths in this series and no immediate or delayed postoperative complications which could be attributed to curare; however, eight patients did have some apnea for a limited time, averaging seven minutes. Before the administration of curare in each subject the respiration was

manually tested by the anesthetist to be sure artificial ventilation could be carried out. In those patients in whom apnea did occur manual controlled respiration was carried out without difficulty. The longest time of apnea was twenty-four minutes. The incidence of apnea was much less in the last of our series than in the first, no doubt due to the fact that we were better able to judge the required individual dose in each patient. Apnea may occasionally occur regardless of the dosage but it is easily relieved by instituting artificial resuscitation by manual rhythmic pressure of the breathing bag. In no patient was it necessary to resort to prostigmine as an antidote to curare.

#### CONTRAINDICATIONS

We found no contraindications to the use of curare when the proper dose was given. In any condition in which manual controlled respiration is contraindicated or impossible, curare should not be used as there is always the danger that apnea may occur and necessitate resuscitation. Patients who have received ether in moderate to large amounts should be given curare very cautiously in small doses. Patients with myasthenia gravis should not receive curare because of existent myoneural weakness.

#### CONCLUSIONS

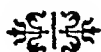
One hundred fifty surgical patients are presented in whom curare was given intravenously during cyclopropane anesthesia by the closed carbon dioxide absorption technic. Curare by its ability to produce effective relaxation of striated muscle without interfering essentially with physiological processes of the body diminishes the oversaturation of the patient with any one anesthetic agent, therefore, curare is a most valuable adjunct to the professional

anesthetist's armamentarium. With curare cyclopropane anesthesia muscle relaxation approaching spinal anesthesia is obtainable. The bowel contraction is not quite that which is obtainable under spinal anesthesia, but the advantage which curare possesses over spinal anesthesia lies in the fact that its circulatory depression and sequelae are much less. The elimination of headache and backache occurring after spinal anesthesia is almost entirely absent following cyclopropane curare anesthesia. There is also an absence of psychological effects and fear which many patients have toward spinal anesthesia.

The occasional occurrence of apnea with curare should not be advanced as an argument against its use because it is easily treated with controlled respiration by a competent anesthetist. One who is not prepared to carry out controlled respiration should not use curare in anesthesia. There are few actual contraindications to the use of curare. As with any drug or anesthetic agent, an intelligent understanding of its usefulness and limitations is paramount and careful attention to physiological details of its administration is imperative.

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# VALUE OF X-RAYS IN THE STUDY OF POSTOPERATIVE EMERGENCIES AND COMPLICATIONS

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IN almost every field of surgery useful aid may be afforded by studies with x-rays in connection with or after operations. It is well known that orthopedists need constant postoperative checks on their operations on bones and joints, the treatment being modified from time to time according to the findings furnished by x-ray studies. The thoracic surgeon has constant need for x-ray guidance in the postoperative management of his patients and in planning subsequent procedures when multiple surgical operations are performed.

In the space allotted the author will touch upon only a few of the surgical procedures in the after-care of which x-ray study is valuable, and he will touch on some of the intra-abdominal conditions in which this help seems most pertinent.

Case I deals with a patient who had recently had an operation for drainage of appendiceal abscess. The high leukocytosis, persistent fever and rigidity of the abdomen suggested that there was a walled-off abscess which needed further drainage but the location of the abscess and consequently the location of the incision for its drainage was not clearly indicated by the physical findings. A scout film of the abdomen was inconclusive, although absence of gas shadows in the lower left quadrant suggested this as the site of the abscess. Accordingly, umbrathor was given by mouth and a film made five hours later showed the opaque material displaced from the left lower quadrant in a manner definitely indicating the left lower quadrant location of the abscess. Surgical drainage liberated more than 500 cc. of pus from a walled-off abscess in the left half of the pelvis extending up into the abdomen.

Case II is another example of the same problem. The patient had had an appendectomy and continued to run fever and a high leukocyte count. The film study made after visualization of the colon with an opaque enema show the cecum and ascending colon displaced mesially (Fig. 1) leaving a large vacant space on the outer side of the cecocolon which indicated that the abscess was located in this area. The surgical incision resulted in drainage of a large walled-off abscess.

It will be noted that the contours of the cecum and ascending colon on the mesial side were characteristic of the normal with the usual haustral markings. On the lateral aspect next to the abscess the wall of the cecum and ascending colon was irregularly serrated.

Case III is still another example of the same type of lesion, and with the displacement of the barium enema the ascending colon was visualized away from the midline. The scout film showed the gas areas in the abdomen everywhere except in the area of the abscess itself, as demonstrated later by the opaque enema filled colon.

In case anyone has hesitancy about the administration of barium or bismuth preparations for the visualization of the colon in those patients with suspected intra-abdominal pathologic conditions with possible obstruction, this fear may be dispelled by the use of umbrathor, an aqueous solution of thorium dioxide, as the opaque medium. This solution is a liquid preparation which has practically as good opacifying qualities as barium. It is advantageous since it remains in a liquid solution at all times.



FIG. 1. Opaque enema showing displacement of the ascending colon toward the midline by large, walled-off post-appendectomy abscess.

There are some pitfalls in the localization of intra-abdominal abscesses and other masses by the method just described. For instance, in the left lower quadrant a loop or loops of redundant sigmoid may form a mass which displaces the small intestine rather conspicuously; an enlarged spleen or enlarged liver may be easily recognized; a retroperitoneal sarcoma may displace the small bowel very conspicuously from the middle of the abdomen. One pitfall is furnished by the bladder. Normally, the small bowel lies in the true pelvis and is lifted out of the true pelvis only by a physiologic enlargement of the uterus, a uterine fibroid, an ovarian cyst or other pelvic tumors, but it may also happen that a filled bladder may lift the small intestine entirely out of the true pelvis only to let it fall back into the true pelvis when the bladder is emptied.

Careful cooperation of the surgeon and the radiologist will often be of great value in the localization of intra-abdominal purulent collections and aid the surgeon materially in selecting a route for approach in performing surgical drainage.

Another group of cases utilizes the recog-



FIG. 2. Gas under both phrenic cupolas in case of ruptured duodenal ulcer.

nition of air under the diaphragm as its cardinal sign. One group of such cases is represented by rupture of a hollow viscus, such as a duodenal or gastric ulcer, an ulcer of the colon, etc.

In Case iv, a film was taken in which it was seen that the right diaphragm was slightly higher than the left as is normally the case when the patient is examined in the upright position. The rays passed postero-anteriorly onto the film held against the patient's anterior chest wall. Under the right diaphragm no air was seen at all; under the left diaphragm we usually find an air bubble surmounting a narrow or wider fluid level, according to the state of filling of the stomach.

In case of rupture of a hollow, intra-peritoneal viscus we utilize the very valuable sign of air under the diaphragm, seen best with the patient in the erect position. (Fig. 2.) A small translucent zone is seen just beneath each cupola of the diaphragm, paralleling it. The only circumstance in which this sign should fail in connection with rupture of a hollow viscus is one in which there are adhesions between the diaphragm, the liver or the spleen. If the patient is too ill to be studied in the erect position, either sitting or standing, it is perfectly feasible to turn him on the left or possibly the right side. According to the circumstances of the case, place a film vertically in front of or behind him and pass the rays through him in a direction parallel with the floor. In this manner the air or





FIG. 3. False diagnosis of rupture of air-containing viscus; case of gangrenous cholecystitis. The postoperative film showed this apparent air pocket under the right diaphragm, with the patient lying on the left side. No gas was found in the peritoneal cavity.

gas in the free peritoneal cavity will naturally seek the highest level and it will be seen between the liver and the lateral thoraco-abdominal wall.

This is a valuable sign but it must be interpreted with some reserve for there are other conditions under which it may be encountered. For instance, following an abdominal operation it is a common observation to recognize a little air under the diaphragm if the patient is examined in the erect or lateral posture, this air being imprisoned in the abdomen at the time of the closure of the abdominal wound. Air in the abdominal cavity requires seven to fourteen days for complete absorption.

Similarly, following insufflation of air into the peritoneal cavity through the uterine canal as a test for tubal patency, some air remains in the abdomen for many days.

When the patient lies upon the left side with the right side uppermost, the film being placed vertically in front of or behind the patient, an aspect (Fig. 3) closely resembling air under the diaphragm between the liver and the lateral thoraco-abdominal wall may be simulated by the relative translucency of the fat lining the abdominal wall and the much denser shadow cast by the liver. This may result in the false impression of air which has escaped from a hollow viscus.

This discussion of air under the dia-

phragm, while not strictly related to post-operative management of surgical cases, is mentioned here to introduce the subject of subphrenic abscess. Ordinarily, there is sufficient question about the diagnosis of subphrenic abscess to warrant the use of the x-ray. The cupola of the right diaphragm normally has a somewhat higher stand than the left phrenic cupola; the difference is usually about 1 cm. This difference may be accentuated if the patient is examined at the bedside with equipment which permits no greater focus film distance than 25 to 30 inches, especially when the film is placed posteriorly instead of against the anterior chest wall. This combination exaggerates the normal, slight elevation of the right diaphragm which then seems to be several centimeters higher than the left. It must be emphasized that this is a normal finding.

A case of subphrenic abscess is that of a woman (Case v) who recently had an operation for a suppurating gallbladder. X-ray revealed that the right diaphragm reached as high as the fourth interspace anteriorly, whereas the left reached only to the sixth interspace measured anteriorly. The contour of the right diaphragm was irregular, especially in the costophrenic angle. There was no fluid level. It is unfortunate that in the majority of patients with subphrenic abscess there is no fluid level to be demonstrated. The abscess is due to some organism which is not aerogenic, so no matter in what position the patient is placed no fluid level can be recognized. In spite of the absence of a fluid level a subphrenic abscess was diagnosed and an operation was performed.

If the patient can be fluoroscoped, however, a lack of movement of the right diaphragm will be noted and some supra-phrenic lung field shadows will be observed which are nearly always present, especially in the late cases, whereas the left diaphragm is freely movable. Of course, one may have a subphrenic abscess under the left diaphragm as well as under the right and in that event the findings indicating





FIG. 4. Right subphrenic abscess (at arrows), patient supine.



FIG. 5. Right subphrenic abscess, patient erect.

pathologic disorders will be on the left side.

The cardinal x-ray signs of subphrenic abscess are elevation and fixation of the diaphragm on the affected side, with complications sooner or later in the way of basal pleurisy above the diaphragm. A third sign is occasionally present as above suggested, namely, gas supernatant above the fluid in the abscess. If the patient is examined in the horizontal position, this gas will be recognized as a shadow of diminished translucency superimposed on the shadow of the liver, provided the abscess occurs on the right side. By placing the patient in the erect or lateral position the sign of a fluid level can be elicited and this shows definitely the location of the abscess cavity. If the patient cannot stand or sit erect, he may be placed on the healthy side, the diseased side uppermost, and a film made with the rays passing transversely across the table or bed parallel with the floor so that a fluid level can be demonstrated if it exists.

Case VI presents in the supine position (Fig. 4) a large gas-containing cavity of somewhat indefinite shape, not at all characteristic. When the patient is placed in the erect position we see on the right side that the diaphragm is completely ob-



FIG. 6. Large right subphrenic abscess, lateral projection, patient lying on left side.

scured, there is evidence of fluid in the pleural cavity above where the right diaphragm probably lies and beneath it on the left side one sees the air-containing fundus of the stomach. (Fig. 5.) By placing the patient on the left side with a film held vertically behind him we obtained a fluid level showing the maximum longitudinal extent of the cavity.

Still another case (Case VII) illustrates the value of the lateral position in the demonstration of a large right subphrenic abscess. (Fig. 6.)

Left subphrenic abscess is considerably more infrequent than a subphrenic abscess occurring on the right but here we have the



FIG. 7. Subhepatic abscess with subphrenic extension shown, several weeks after drainage by opaque-enema study, to be due to ruptured appendix; barium in abscess cavity shown at arrow.

possibility of other aids in locating the abscess cavity.

Another example is that of Case VIII. X-ray study indicated that the left phrenic contour was indistinct; there was some left basal pleurisy and a homogeneous shadow with just a little air above it in the film, made in the usual manner with the patient horizontal, the film beneath him and the tube above him.

However, by having this patient stand erect, which he was able to do, we observed the left diaphragm about 1 inch higher than the right; we found a blunting of the left costophrenic angle, indicating the presence of a small pleural effusion, and we saw the abscess cavity nicely delineated by a fluid level with gas above it beneath the phrenic cupola, and the mesial contours of the abscess were easily seen by contrast material in the stomach. The stomach was seen to be depressed and displaced toward the midline away from the abscess. This patient had had a partial gastrectomy by the Polya method and this makes a very striking roentgenogram. This case is interesting and very

unusual in that the patient was treated by careful observation from day to day without the use of surgery and finally under rest treatment alone the signs of the abscess disappeared.

It is possible to determine the excursion of the diaphragm with the patient lying in bed, without the use of the fluoroscope and by employing a film underneath the patient making a double exposure—one made at the end of inspiration and one at the end of expiration. On the resulting film a single phrenic contour will be seen on the affected side with a motionless diaphragm in the case of subphrenic abscess (and in liver abscess also), whereas on the unaffected side the excursion of the diaphragm will be demonstrated by two distinct phrenic contours.

The technic for making these films requires some care. It is better to employ relatively long exposures with low milliamperage than one that is too short. The film is placed under the patient and the estimated exposure is divided into two fractions, 5 to 1. The patient exhales completely and an exposure one-sixth of the total is made, then the patient is asked to inhale fully and the remaining five-sixths of the exposure is given. This technic must be followed exactly if one wishes to get satisfactory results.

X-ray study is also useful in determining the efficacy of subphrenic abscess drainage. A film taken of Case IX illustrated the position of the drainage tube. It could be seen that there was no longer any fluid level in the abscess cavity which was, therefore, perfectly drained.

I wish to cite still another most interesting case (Case X) of subphrenic abscess. The patient, Mrs. P., aged forty-three years, entered the hospital on October 1, 1940, suffering from abdominal pain of six days' duration. She had had generalized aches for five days and chills and fever for one day. She was thought to have pelvic peritonitis and was treated accordingly. Several indistinct pelvic masses were felt but there was no "freezing" of the pelvis.

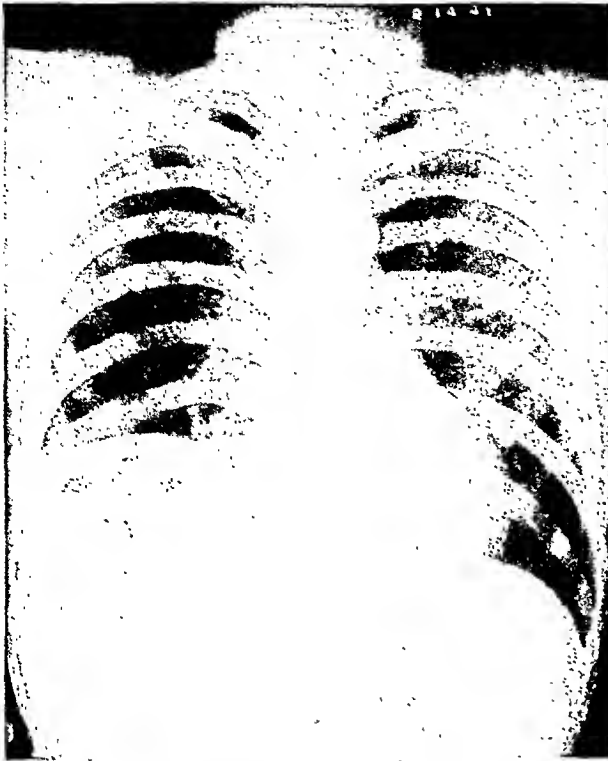


FIG. 8. Amebic abscess of liver, patient erect, projection postero-anterior.



FIG. 9. Amebic abscess of liver, lateral projection; patient erect.

The leukocyte count was 21,800, 29,200 and 28,000 on three successive days.

On October 23rd, the mass in the right side of the abdomen and pelvis had become so large and the symptoms so urgent that it was decided to drain what was thought to be an ovarian abscess the size of a grapefruit. The leukocyte count was 29,000 and the sedimentation rate thirty-six minutes. Preparations were undertaken to operate within two or three days but the next day she exhibited evidence of shock with signs of spreading peritonitis and was treated with blood transfusions and parenteral fluid.

On November 7th, physical examination of the chest gave the impression of a high, right diaphragm with crepitant râles over the base. The diaphragm appeared to be fixed on both sides; the abdominal mass seemed to be lobulated, and she was thought to have multiple abdominal abscesses.

X-ray examination at the bedside was then ordered which revealed a large subphrenic abscess on the right side, not the left as was anticipated, the

abscess containing sufficient gas for satisfactory visualization.

On November 9th, the subphrenic abscess containing a liter or more of thin pus was evacuated. Following this the patient made excellent progress for five days but on the sixth day the nurse reported fecal matter in the drainage wound. A colon study the following day by the use of a contrast enema showed the tip of the inverted cecum well up under the edge of the liver and we were able to observe the passage of opaque material from the tip of the cecum into the drainage tract and out onto the dressings. (Fig. 7.) Thus the origin of the subphrenic abscess in a ruptured subhepatic appendix on the tip of an inverted cecum was rather clearly demonstrated.

By way of contrast and for instruction a case of amebic liver abscess will be cited. One might think that the relative thinness of the shadow of the cupola of the diaphragm in subphrenic abscess, as contrasted with the thickness of the shadow of the diaphragm plus a certain portion of the liver wall, would aid in the differentia-



FIG. 10. Case of cholangiography, opaque material being injected through drainage tube to determine patency of common duct. Thorotrast is seen passing into the common duct and also into the pancreatic duct. The biliary radicles are well visualized.

tion between liver abscess and subphrenic abscess but this is not a dependable scheme of differentiation.

In a patient with liver abscess (Case x1) we dealt with a young man who had all the clinical signs of an amebic affair. The first x-ray films showed flattening and elevation of the right phrenic cupola but significantly without the supraphrenic basal pleural manifestations so commonly seen with subphrenic abscess.

A film was made with this patient lying in the supine position in which the enlargement of the liver could be appreciated but we did not see any fluid level in either of these films. Evidently the abscess was not complicated by an aerogenic organism. After surgical consultation the liver was explored by aspiration through the lateral abdominothoracic wall and about 300 cc. of purulent pus was withdrawn, after which 200 cc. of air was introduced into the abscess cavity. This cavity was clearly shown by reason of the fluid level. Two films (Figs 8 and 9), standing postero-anterior and lateral-erect projection, all show the abscess very nicely. Under appropriate anti-amebic therapy the abscess

was cured without any further surgery than this drainage.

If a liver abscess is not due to an aerogenic organism, its recognition will be most difficult. Some value is attached to the fluoroscopic observation of the excursion of the diaphragm which may be carried out very carefully from day to day. As the abscess grows larger, the movement will become less pronounced, until finally the excursion of the diaphragm will cease on the liver side. The intravenous injection of thorotrast will help in the visualization of a hepatic abscess, but considerable objection to this medication has been raised. It is taken up by the reticulo-endothelial cells of the liver and spleen and retained there for the life of the patient. Yater has demonstrated that a single injection of 25 cc. of a 25 per cent colloidal preparation known as thorotrast is well within safe limits and to be recommended for the recognition of intrahepatic abscess.

Another group of abdominal operations in which the aid of x-ray is of great value includes operations on the biliary tract. We are all familiar with the great aid furnished by cholecystography in the

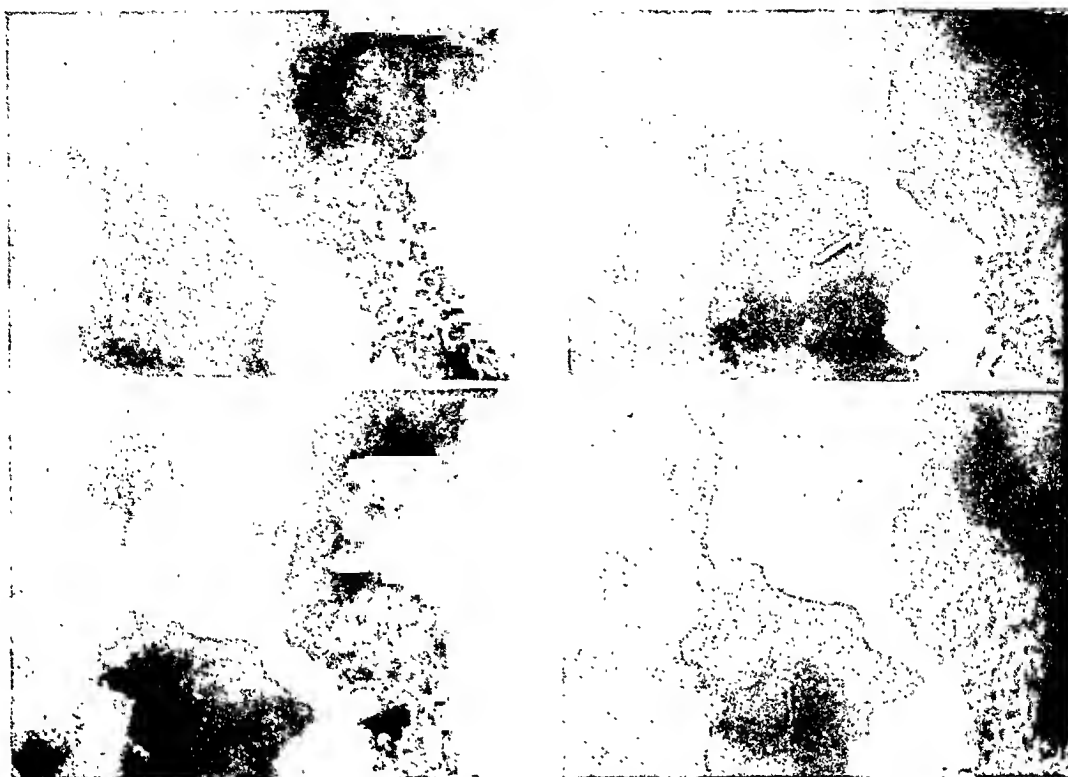


FIG. 11. Four serial films showing gastrojejunal ulcer following partial gastrectomy.

diagnosis of gallbladder disease, but there is not such great familiarity with the value of an x-ray examination at the time of surgical intervention and for postoperative examination. It is now becoming common practice for the surgeon to call on the radiologist to have the necessary x-ray equipment set up in the operating room before the operation begins. At appropriate moments during the operation the bedside x-ray instrument can be wheeled into position with the tube over the operative field, the film placed in the film holder underneath, and an exposure made in a fraction of a second. The surgeon introduces some form of opaque material, preferably thorotrast, into the gallbladder or common duct when he wishes to visualize the biliary tract and particularly to determine whether or not the common duct is patent or harbors stones which have eluded his operation.

The biliary radicles are nearly always visualized in these cases, apparently without doing any harm at all. The dilated common duct shows up nicely and stones, if present, are seen as filling defects in the shadow. On the other hand, if the opaque material passes readily into the small

intestine, the patency of the common duct can be assured. Sometimes following operations, cholangiography through a drainage tube or a biliary fistula has value in cases in which a persistent stone is suspected or in which it is desired to determine the full patency of the common duct before removing the drainage tube from the common duct. (Fig. 10.)

The patient in Case XII had gallbladder surgery for suspected gallstones. The surgeon did not find any gallstones; in fact, he thought the gallbladder was normal. But having made the abdominal incision, he decided to "just drain" the gallbladder. Accordingly, he tied a drain into the fundus of the gallbladder and closed the wound. After a few days the drainage tube was removed and the wound allowed to heal up. The patient developed a series of colicky attacks which led to a re-examination with cholecystography revealing non-visualization of the gallbladder. Due to the urgency of symptoms, the probability of shackling pericholecystic adhesions and the non-visualization of the gallbladder with the dye, the gallbladder was removed. In the cystic duct an inch-long piece of heavy



FIG. 12. Jejuno-gastric invagination following partial gastrectomy.

silk of the type sometimes employed in surgery was found. It was evident that in connection with the tying of the drain into the fundus of the gallbladder this piece of silk found its way into the gallbladder and later into the cystic duct, blocking it.

Another group of postoperative cases involves operations upon the stomach. Nearly every surgeon who does operations upon the stomach finds it useful to make postoperative studies to note the modified form of the stomach or the stump of the stomach for the purpose of verifying the position of the anastomosis in relation to the body of the stomach, and to note the time required for gastric clearance. Partial gastrectomies have almost entirely replaced gastroenterostomies in the treatment of those cases of duodenal ulcer for which surgery is required. The operation of gastroenterostomy has fallen into great disrepute and is now seldom done except as an emergency measure. This came about as every physician knows, through the frequent appearance of postoperative gastrojejunal ulcers occurring in or near the gastric stoma. However, the partially gastrectomized patients are not immune

to this serious and unpleasant complication, and we are frequently asked to study a case following a Polya or other type of gastric resection to see if we can determine the presence of a gastrojejunal ulcer.

There are, of course, numerous cases in which gastroenterostomies have been done

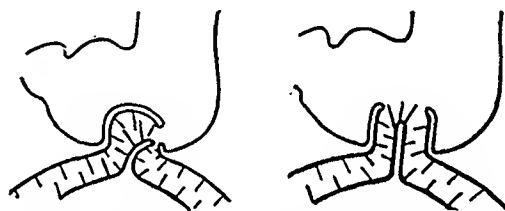


FIG. 13. Three drawings from Zerboni (*Arch. urug. de med., cir. y especialid.*, 14: 615 1939). Above, normal new gastrojejunal stoma; below to left, simple invagination of one loop; to the right, double invagination.

with no subsequent complications and the patients have been entirely satisfied. An examination of a patient (Case XIII) who twenty-five years ago had a gastroenterostomy, showed it to be functioning perfectly. The patient made no complaint whatsoever and said that he had forgotten he had a stomach. The gastroenterostomy was made exactly at the lower pole of the greater curvature; no food passed through the old pyloric canal and there was found no retention of barium in the excluded portion of the duodenum and jejunum. Evidently it was a short-loop posterior gastroenterostomy.

Various complications may arise following a gastroenterostomy, one of which

is stenosis at the site of the stoma. In Case XIV a gastroenterostomy had been done eight or nine years previously. The patient got along nicely until within the last year he had been developing periodical spells of abdominal distress, in the course of which he felt a fullness in the epigastrium and actually could feel a fluctuating tumor in the midline and just to the right of it.

Under x-ray examination it was easy to determine that this patient had a gross dilatation of the duodenum and a number of inches of the jejunum, and a diagnosis of gastrojejunal obstruction was easily justified. At surgery the diagnosis was confirmed. Several of my slides show the gross dilatation of the jejunum and duodenal curve, the barium passing into the stomach, through the old pylorus into the duodenum, and around to the site of the anastomosis where the obstruction occurred. Fluoroscopically, it was observed that this duodenum and jejunum sometimes enlarged to a caliber of two and a half or three inches. At operation the gastroenterostomy was taken down, the pyloric half of the stomach was resected and a typical Polya operation done with excellent relief.

Among the various indications of *gastrojejunal ulcer*, spasm with obstruction at the new opening and particularly the demonstration of an ulcer crater are the cardinal signs. Localized tenderness on pressure over the suspected ulcer crater is of important confirmatory value. These ulcers are usually seen to occupy a position in the efferent loop of jejunum (Fig. 11) more or less in the first inch below the gastrojejunostomy opening.

A sleeve resection, that is, the resection of the middle third of the stomach, to remove an ulcer on or near the lesser curvature of the corpus ventriculi, is an operation which looks very nice at the time but at the postoperative x-ray examination one is always disappointed to find that while the upper third of the stomach functions normally, just as do the remnants of the stomach after Polya resections, the



FIG. 14. Case of meteorism three days postoperatively; suspected acute intestinal obstruction. Bedside roentgenogram shows gas in the colon, not in the small bowel.

lower portion of the stomach below the line of suture serves merely as a tube through which the food passes, the peristaltic activity in the lower part of the stomach practically disappearing. One also finds ulcers occurring on the lesser curvature at the site of the anastomotic line.

Still another complication which may follow gastrojejunal anastomosis is the retrograde invagination of a loop of small intestine through the new stoma into the stomach. This may occur as a single invagination of the afferent loop or an invagination of both the jejunal loops, the mass of intussuscepted bowel forming a tumor-like filling defect in the stomach which is easily recognized with the x-ray.

The roentgenogram of Case xv are significant. One recognizes easily the filling defect (Fig. 12) in the shadow of the gastric stump due to the invagination of small intestine following a gastric resection and gastrojejunostomy. The next few slides I show you are illustrations of similar accidents taken from the literature. (Fig. 13.)

A gastrogastic invagination may occur in an unoperated stomach, the invaginated





FIG. 15. Gas arcs following operation for suppurative appendicitis, quite convincing that ileus is present without the use of opaque material.



FIG. 16. Same case as Figure 15. Because of considerable delay in deciding to operate, barium was given by mouth and within a few hours afforded conclusive demonstration of small bowel obstruction.

portion of the pyloric end of the stomach having become intussuscepted into the major portion of the body of the stomach. This gives rise to a form of prepyloric narrowing resembling very much some of the baffling annular deformities with persisting mucosal pattern, which are occasionally encountered and which give rise to great perplexity.

The question of x-ray evidence of intestinal obstruction is one in which your speaker has long been interested. It seemed elementary that if on opening the abdomen in a case diagnosed as acute intestinal obstruction one found dilated loops of small intestine with a diameter of 2 or even 3 inches, and he recognized this as visual proof of the obstruction, the same information could be obtained by x-ray examination.

In 1915, I reported before the American Medical Association meeting in San Francisco on a series of studies in which I related my experience in the determination of acute small intestine obstruction in this

manner.<sup>1</sup> Patients were examined at the bedside. Nowadays we have much better equipment for this purpose. A film holder or a cassette containing a film is placed under the patient while an assistant on each side of the bed lifts the patient simply by raising up the draw sheet. The film is slipped under the patient's abdominal area with no more disturbance than that necessary to raise him up in changing the sheets on the bed or in the use of a bed pan. A film is exposed and developed, and within a few minutes one has the graphic record of the degree of distention of the abdominal coils. At first we believed it necessary to give the patient some opaque material to visualize the intestines, but it soon became apparent, especially in postoperative cases, that the gas distention of the bowel had a characteristic pattern which made it easy to recognize in the majority of cases the presence or absence of ileus.

In Case xvi the patient was operated upon three days previously, and the abdominal distention and accompanying



distress raised the question of acute intestinal obstruction. The roentgenogram at once revealed that the patient had a greatly distended colon (Fig. 14), and the colon thus visualized by its gas content was so clearly recognizable because of its haustral contours that one could have no doubt that it was the colon and not the small intestine which was air- or gas-distended. It is, of course, possible to have an acute obstruction of the large bowel, but in my experience such colonic obstructions constitute only about 5 per cent of the cases of acute intestinal obstruction. Therefore, in such a case as this it was a simple procedure to introduce a rectal tube and a small amount of enema at which time the patient promptly expelled the gas from the colon and obtained relief.

Case XVII was a similar case. One recognized the colonic gas by the haustral contours of the colon in contrast to the parallel cross markings of small intestinal loops, to which the term "herring bone" shadow has been applied. With small intestinal obstructions one also finds a parallel "stepladder-like" arrangement of the small bowel, a finding long ago observed by the masters of surgery.

Our Case XVIII was one of acute small intestine obstruction following operation. In this case the characteristic stepladder or parallel arrangement of coils of small bowel was seen. That these coils were small bowel coils was easily recognizable by the markings of the valvulae conniventes giving origin to the so-called herring bone appearance.

It was learned that in the average case it was not necessary to administer opaque material. I formally called attention to this fact in 1915, although I had been teaching it several years before that date. In my earlier experiments I always gave the patients a small amount of barium. It seemed to do no harm in the small quantity given. In one series of 200 consecutive abdominal cases, including some cases of suspected ileus, I made postoperative studies on the third postoperative day

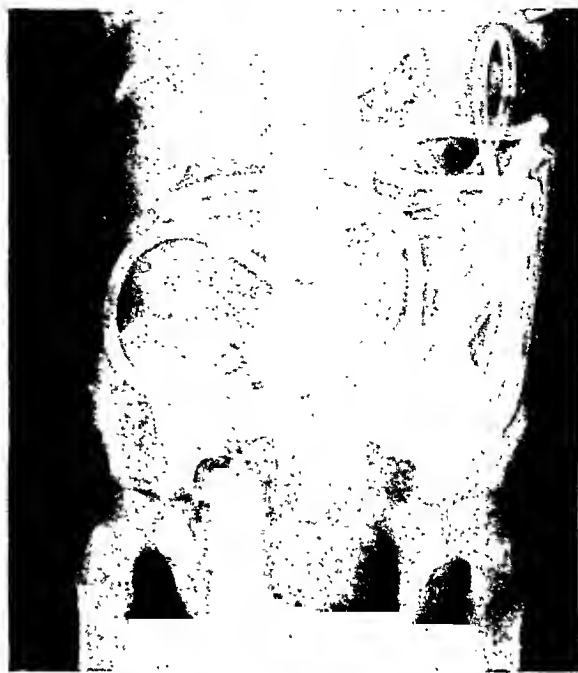


FIG. 17. Small intestinal intubation.

after administering on the afternoon of the second day a small quantity of barium by mouth, the barium being suspended in a sugar-water solution. In no case was there noted any disturbing complication from the use of the barium in this amount. The total amount of barium given need not exceed a rounded tablespoonful in most cases. This barium stirred in water or glucose solution may be introduced through a stomach or duodenal tube, or it may be administered to the patient in teaspoonful doses, even in presence of vomiting matter suspected of having fecal origin. In such a case I have seen the opaque material pass on down the intestines into the small bowel in six or eight hours in a quantity sufficient to identify it beyond any question as small bowel.

Some have emphasized the importance of examining the patient in the erect position. Placing the patient in such position imposes upon him a strain which in very ill patients is not to be undertaken. In such cases the patient may be laid upon the right or left side, a film placed vertically in front of or behind him and the rays passed through the body parallel with the floor. This is a maneuver which will demonstrate a fluid level. However, we found it rather



FIG. 18. Case of ileus. Symptoms began sixteen hours before this film, which shows characteristic small bowel distention, was taken. Operation was performed at once. Gangrene had already taken place. The use of intubation would have occasioned fatal loss of time.

difficult to differentiate between the fluid levels of dilated small bowel and the fluid levels in the colon or stomach. They are rather confusing, and the author usually does not attempt to determine a fluid level except in those few cases in which there has been some question.

In our Case XIX the small bowel was readily recognized as such because of the herring-bone appearance visualized by the umbrathor. This same aspect may be obtained by the same maneuver without the administration of opaque material.

Because of objections still raised by many to the introduction of a small amount of barium into the intestinal tract of a case suspected of acute obstruction, the author has for more than fifteen years employed an aqueous solution of thorium dioxide, called "umbrathor." This may be administered to the patient in the quantity of 1 ounce of umbrathor to 2 ounces of water, repeated if necessary. The thorium never precipitates out but remains in solution. I have used it in many scores of cases

without the slightest objection on the part of the referring physicians.

In any case in which the simple gas shadows of the abdominal area are not conclusive or when for any reason operation or other treatment is delayed because of disagreement about the diagnosis or lack of consent of the patient, it is my practice to administer umbrathor at once; because within a few hours the gas shadows of the suspected bowel may be reinforced by the contrast afforded by the umbrathor and the roentgenogram becomes more convincing.

Figure 15 in Case XX the gas areas of the abdomen are quite convincing without the use of any opaque material. This boy had undergone an operation for a suppurative appendix and it was easy to suspect that he had ileus, but because of the objections of the parents operation for the obstruction was postponed until twelve hours later. Meanwhile, some barium had been given by mouth and Figure 16 shows the extensive and conclusive demonstration of small bowel obstruction afforded by the contrast material.

Today when small intestinal intubation has become popular as a treatment of obstruction or as a means of preparing an obstructed case for surgery for relief of the obstruction, the x-ray study has become doubly necessary. Sometimes the tube passes into the bowel for a very long distance as is shown in Figure 17.

The use of the tube is attended, however, by a certain danger of delay. Mechanical obstructions may be followed very promptly by tragic, local circulatory disturbances and fatal complications. It is therefore necessary to take into account very carefully the history of the patient, as is illustrated in the following case: Figure 18 shows a case (Case XXI) in which the symptoms had begun only sixteen hours before this film was made. Up to that time there had been no symptoms. Within a couple of years the patient had had an operation for some pelvic tumor. Following the operation there had

been no untoward symptoms until sixteen hours before this film was made. Characteristic small intestine distention was recognized, and because of the history, physical findings and the great probability that the obstruction was due to adhesions, operation was performed at once. Already gangrene had set in and it was necessary to remove fourteen inches of small bowel.

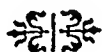
It seems to me that it places a very grave responsibility upon any physician who delays operation in the presence of convincing signs of acute intestinal obstruction, especially involving the small bowel, lest he overlook a case in which mechanical obstruction is followed by

gangrene and a fatal delay ensue while attempting to use intestinal intubation.

The foregoing remarks are not meant to constitute a comprehensive discussion of the value of the x-rays in the management of surgical cases, having in mind particularly postoperative care. The space allotted would not permit such a comprehensive paper. A number of illustrative cases have been cited for some of the more common surgical complications.

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BLAST injury to the lung may be strongly suspected with hemoptysis, pain in the chest, dyspnea and cough. At first, there may be only shock. A short time later, the respiratory evidences appear. X-ray examination of the chest shows varying degrees of confluent consolidation which resembles strongly the findings in acute left heart failure, broncho-pneumonia, or the picture with acute gas poisoning.

From "Principles in Roentgen Study of the Chest" by William Snow (Charles C. Thomas, Publishers).

# EFFECT OF GLYCERITE OF HYDROGEN PEROXIDE UPON HEALING TIME IN ANORECTAL SURGERY

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THE local postoperative conditions following anorectal surgery performed however aseptically leave raw areas which are exposed to bacteria, chiefly staphylococci, streptococci, *PS. pyocyaneus* and *E. coli* as originating both from the surface of the body and from the colon. The subsequent tissue reactions due to the effects of surgical interference, trauma and such bacterial contamination are not those which usually follow infection, since with adequate drainage there is little or no swelling; yet with the invariable infection healing by first intention is rare. The healing process attendant upon anorectal surgery has, therefore, been regarded as slow and any treatment which lessens such healing time is deemed worthy of report. The present paper is concerned with the effects of glycerite of hydrogen peroxide, a non-allergic, hygroscopic, bacteriostatic and bactericidal solution, which used as a postoperative wound dressing has affected the healing time of those of our patients subjected to anorectal surgery.

Glycerite of hydrogen peroxide consists of hydrogen peroxide dissolved in glycerol. It may be prepared by using water-free, pure hydrogen peroxide (92 per cent) in water-free glycerol or by using the addition product, urea hydrogen peroxide crystals dissolved in glycerol, as a source of water-free hydrogen peroxide. The concentration of urea peroxide (4 per cent) furnishes a solution containing approximately 1.5 per cent of hydrogen peroxide. The stability of the solution<sup>1</sup> and its antibacterial effects<sup>2</sup> have demonstrated that at room temperature there is little or no deterioration for periods of more than one year, while it is bactericidal for the gram-positive organisms, *Staphylococcus aureus* (FDA strain

209), *Streptococcus* (alpha hemolytic), *Streptococcus* (beta hemolytic) *Enterococcus* and *Micrococcus epidermis*, as well as the Gram negative organisms, *P. mirabilis*, *PS. pyocyaneus*, *E. coli*, *A. aerogenes* and *E. typhosa*. It is bacteriostatic for the diphtheroids.

Tissue tolerance studies<sup>3</sup> on one hundred normal individuals and in over six hundred patients with infections of the skin and mucous membranes demonstrate that at the 95 per cent level of likelihood, irritation would be expected in less than 1 per cent of the general population. By general nature the solution is hygroscopic, non-allergenic, non-irritating and non-toxic, although dehydrating effects may follow its prolonged use. No irritation was seen in any of the patients studied.

For the present report ninety-four patients were studied over a period of six months. The diagnoses were as follows: fifty hemorrhoidectomies, twelve fistullectomies, fifteen excisions of anal ulcers, anterior and posterior, three large sacrococcygeal sinuses, twelve abdominoperineal resections and two pelvirectal abscesses. In all of the first three groups of this series a general anesthetic with pentothal sodium was used and local anesthesia with zylcaine\* injection (10 to 20 cc.) was administered perianally. It has been our practice to use a gentian violet compound<sup>1</sup> containing 1 per cent pontocaine, 3 per cent gentian violet and 10 per cent tannic acid as a postoperative dressing applied daily, both in the present series and those treated surgically in the past. The results, therefore, are not due to the action of the gentian violet compound. On the third postoperative day of the present series the affected

\* Supplied by Abbott Laboratories.

area is treated with an application of glycerite of hydrogen peroxide applied full strength with large cotton swabs to the lower rectum, anal canal and perianal areas. The patients are permitted up on their first postoperative day and their first evacuation occurs by the second or third postoperative day. They are usually discharged on the fourth or fifth hospital day and are furnished with a supply of the solution to apply three times daily at home. Subsequent office treatment consists of the application of glycerite of hydrogen peroxide and gentian violet compound three times weekly until healing is complete.

In an equal number of patients seen before we instituted treatment with glycerite of hydrogen peroxide, the healing time from the operative day to final discharge was from seven to eleven weeks, with an average healing time of eight weeks. In the present series of seventy-seven patients who underwent surgery involving the anorectal canal, the healing time varied from three to four and one-half weeks, with an average of four weeks, or just half the length of time before using this solution. Furthermore, hot wet dressings which had been used in the past as routine procedure to aid the exudative process and promote healing have been used in this series only for the relief of pain following evacuation. Such applications were necessary in only seven of the seventy-seven patients in this series. In patients who had undergone radical excision of large sacrococcygeal sinuses, healing time required from fourteen weeks to as long as four months. In the present series of three patients it was reduced to an average time of eight weeks.

Glycerite of hydrogen peroxide has been used in cleansing the posterior cavity following abdominoperineal resection one or two times daily. We have not irrigated a posterior cavity in the past year. When clean, healthy granulation tissue has formed after cleansing with the solution twice daily, the area is covered with powdered red blood cells, lyocyte powder,\* a pro-

\* Supplied by Sharp & Dohme.

cedure which has been most beneficial to rapid healing. In this series of twelve patients the healing time varied from eight to ten weeks, while in an equal number of patients seen before we instituted the treatment the healing time varied from eighteen to seventy-four weeks. Furthermore, in five cases when glycerite of hydrogen peroxide was applied to cavities which seemed to resist complete healing, final epithelization was accomplished after one or two applications.

In two patients with pelvirectal abscesses, healing took place in eight weeks. In two patients seen before this treatment with glycerite of hydrogen peroxide was instituted, healing time was sixteen weeks. None of these patients in this complete series showed any signs of irritation or overgrowth of granulation tissue. However, a small percentage of the patients complained of a burning sensation which was of very short duration.

#### CONCLUSIONS

Healing time following anorectal surgery was reduced approximately one-half since treatment with glycerite of hydrogen peroxide was instituted.

Patients have been more comfortable during their hospitalization through the elimination of hot wet packs, formerly used routinely to promote the exudative process and stimulate healing.

The necessity for nursing care has been greatly reduced in these times of crowded hospital conditions.

The oil-soluble anesthetic used routinely, 10 cc. to the posterior quadrant and 10 cc. to the anterior quadrant of the perianal area, has eliminated the laryngeal spasm and stimulation of the respiratory center from dilatation of the anal sphincter.

There was no postoperative perianal abscesses from the use of the oil-soluble anesthesia.

The cleansing of posterior cavities in abdominoperineal resections with glycerite of hydrogen peroxide followed by the applica-

tion of lyocyte powder has markedly decreased the healing time over the use of the powder alone.

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FISSURE in ano is not uncommon in infants or in older children. The etiology is usually traumatic, produced by the passage of hard feces, and the location is usually posterior. The basic factor is, of course, constipation. Diarrhea, with its attendant straining and frequent irritating passages, may also initiate an anal fissure.

From "Ambulatory Proctology" by Alfred J. Cantor (Paul B. Hoeber, c.)

# TENDON TRANSPLANTS FOR RADIAL AND ULNAR NERVE PARALYSIS\*

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IT is our purpose in this paper to describe the technics used at the Cushing General Hospital to obtain good functional results in cases of irreparable destruction of radial and ulnar nerves. In no instance have we found it possible or advisable to carry out a combined tendon transplant for ulnar and radial nerve palsy in the same hand. The number of tendon transplants for radial palsy have been numerous, whereas the entirely new technic for ulnar nerve palsy has been applied to less than six cases.

## GENERALIZATIONS

Concomitant with the routine preoperative examination, a clear mental picture should be formed of exactly what type of procedure is to be followed. Needless to state, no reconstructive tendon work should be contemplated on a completely anesthetic hand. Following primary nerve anastomosis and such signs of nerve regeneration as burning, hyperesthesia and other sensory changes beyond the site of nerve repair, it can be assumed that satisfactory progress will continue, and then and only then should tendon grafts and transfers be done.

In those instances in which bone grafting has to be carried out, tendon work should be postponed until there is both clinical and x-ray evidence of union, which varies in the main from eight to twelve weeks. It has been our experience that bone reconstruction of the metacarpals is usually followed by shortening and thickening of the associated metacarpophalangeal collateral ligaments with hyperextension of the fingers, thus preventing flexion at the knuckle joint.

Therefore, it is best in such cases to

excise collateral ligaments prior to definitive tendon work and to maintain the digits in a flexed position with the aid of a Bunnell hand splint (Fig. 1) for several weeks prior to definitive tendon work. With the aid of physiotherapy and frequent finger exercises, this deformity is easily overcome, and then tendon transplants can be made successfully.

We have tended to carry out either ulnar or median nerve repair in conjunction with tendon transfers provided there is not an extensive loss of nerve substance. However, a loss of more than 3 or 4 cm. of nerve substance in the wrist and forearm in cases of median or ulnar nerve injury usually means that the wrist and elbow joint must be markedly flexed to approximate the nerve endings. Under such conditions it is better to postpone all tendon work until there is evidence of nerve regeneration.

When the tissues in the hand, wrist or forearm are obviously in poor condition and there is a marked degree of cicatrix, it is best to consider antebrachial or triceps fascial transplants to provide an adequate sliding mechanism. Occasionally, records of previous hospitalizations indicate that denuded bone surfaces will be encountered. In such cases fascial transplants are a necessity. An excellent sliding mechanism will be found where huge skin defects have been filled in with abdominal pedicle flaps. Ordinarily in such cases the site of the missing subcutaneous tissue will be supplied with a fair amount of subcutaneous fat. Tendon transplants or grafts can be tunneled through such adipose tissue, thus simulating, in a way, the epitendineum.

In those instances in which flap operations or bone grafts have been followed by any degree of sepsis, whether superficial or

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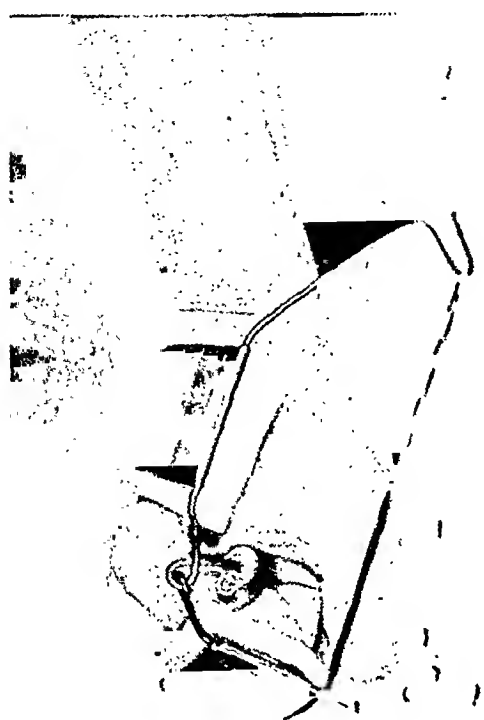


FIG. 1. A Bunnell hand splint devised to promote flexion at the metacarpophalangeal joints of the fingers.

deep-seated, surgery should be postponed at least eight to ten weeks after the infection has completely subsided. The chances of recurrent infection are very great indeed if any type of extensive procedure is attempted prior to this time interval. The majority of infections have responded well to penicillin administered both locally and intramuscularly. However, an occasional mixed type of infection will become resistant to this drug because gram-negative bacilli are prone to produce a penicillin inhibiting enzyme "penicillinase." The more superficial wounds have, in our experience, responded well to either streptomycin or a parachlorophenol-penicillin mixture. For the more extensively infected and deep-seated septic conditions of this type, a combined course of intramuscular and topical applications of streptomycin is more to be desired. A word of caution should be added here. When streptomycin has been used in too small amounts, bacteria tend to become "streptomycin-fast."

It is best to run streptomycin sensitivity tests in those instances in which this drug is deemed necessary in order that, first, it can be determined if the drug is to be of any value at all, and second, to ascertain the amount of the drug necessary to combat the bacteria in question.

The degree of functional return following tendon transplants will also depend on the condition of the joints involved. The importance of physiotherapy and passive exercises should never be underestimated. Supple joints will rarely become stiff or ankylosed during the customary post-operative period following tendon transplants. The patient must be thoroughly imbued with the idea that he is playing a major rôle in the recovery of the function of his hand. Rather frequently men with several years of overseas service followed by prolonged hospitalization tend to become discouraged and fail to play their part in this reconstructive activity. A non-cooperative patient may prefer amputation to any reconstructive procedure. Quite naturally motion will be at a minimum when the extremity is first removed from the plaster, and this phase should be thoroughly described and explained to the patient beforehand. In many instances we have been able to prognose successful results by an optimistic mental outlook on the part of the patient preoperatively. Individual problems at home can often be solved with the help of the Red Cross and similar agencies, thus allowing the recipient of surgery to concentrate on nothing else but the end result of surgical repair.

#### RADIAL NERVE PALSY

Typical dropped-wrist deformity as the result of radial nerve damage should be treated primarily by end-to-end suture with the wrist held in cock-up position pre- and postoperatively. A gap of up to 8 cm. can usually be overcome by freeing the nerve in the arm and maintaining the elbow in flexed position in plaster. The question arises as to how great a time interval should elapse before the patient is subjected to a



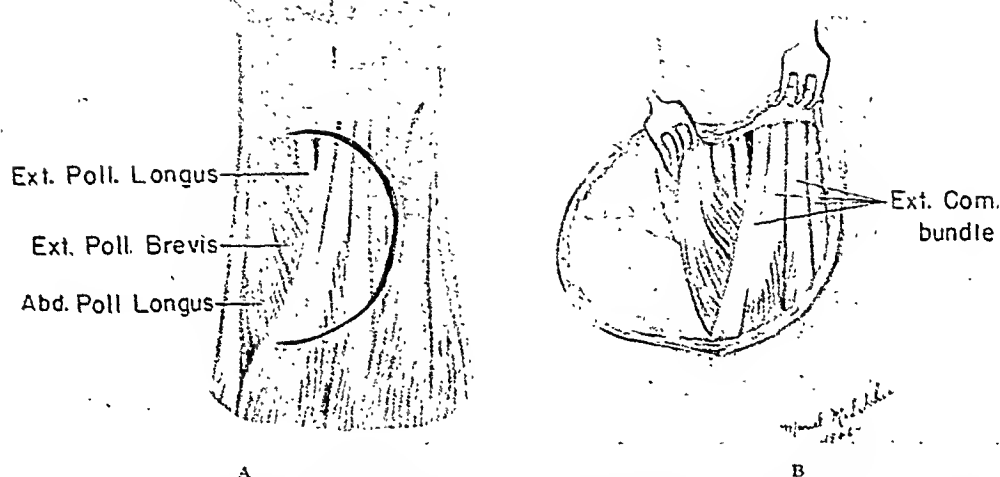


FIG. 2. A and B, C-shaped incision over the dorsum of the wrist exposing the extensor tendons of the thumb and fingers.

tendon transfer. We believe that a total of four months is a maximum figure provided there have not been any signs (including Tinel's) or symptoms of return of function in the interim. Since the repaired radial nerve regenerates at a rate of 2 to 3 mm. per day, four months should be ample time regardless of how high the nerve has been divided. Because of universally poor results with nerve grafts in this procedure, they are to be discouraged. It is better to have a tendon team in readiness at the time the nerve is first explored, so that if the nerve gap is too great to be overcome by a freeing up procedure and the operation has not been too lengthy, a tendon transfer can be carried out immediately. This is more satisfactory than subjecting the patient to a second operation at some later date. Naturally, both the flexor carpi ulnaris and

the flexor carpi radialis are examined pre-operatively to determine their functional state. All operative procedures of this kind can be best performed with a pneumatic type of tourniquet inflated to 300 mm. of mercury about the upper arm.

The operative procedure consists of making a C-shaped skin incision over the dorsum of the wrist just proximal to the dorsal transverse carpal ligament. At this point, the extensor communis bundle to the second, third, fourth and fifth fingers are identified. Through the same incision, the extensor pollicis longus, the extensor pollicis brevis and the abductor pollicis are likewise identified, as illustrated in Figures 2A and B.

Now returning to the volar aspect of the forearm, a long L-shaped incision is made with the base of the "L" just proximal to

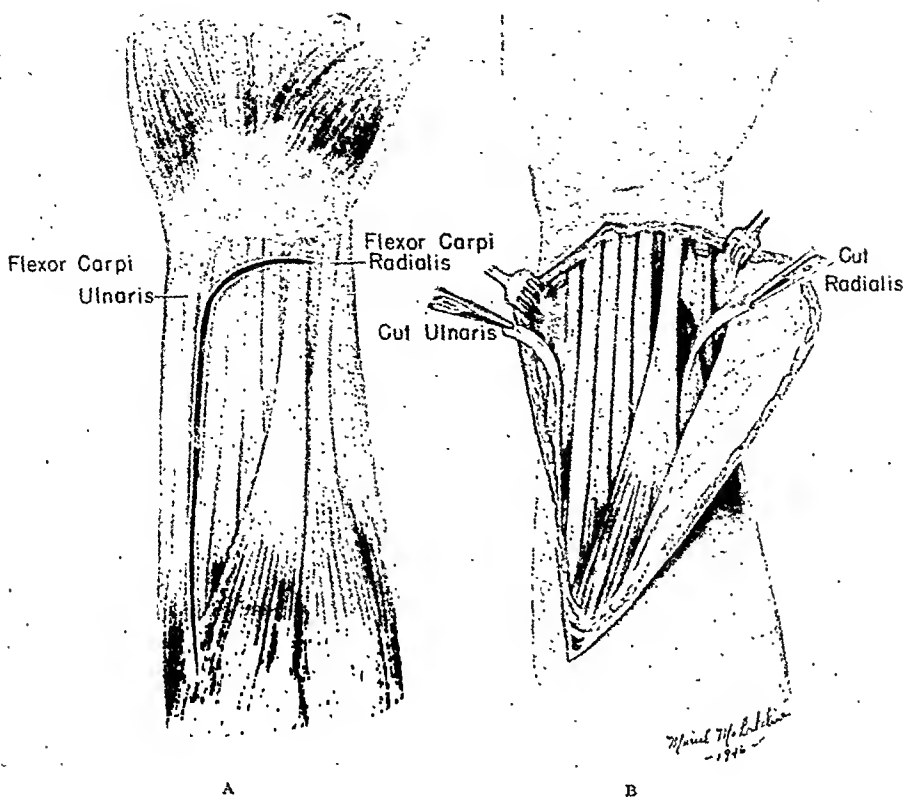


FIG. 3. A and B, L-shaped incision over volar aspect of wrist for division of flexor carpi radialis and flexor carpi ulnaris.

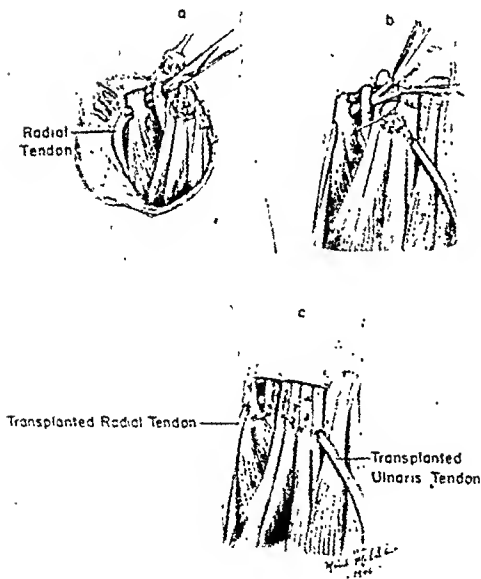


FIG. 4. A, B and C, the flexor tendons implanted into the extensor groups of the thumb and fingers.

lateral to the flexor carpi ulnaris, as shown in Figures 3A and B.

The ulnaris is then divided just proximal to its insertion on the pisiform bone. As the muscle belly of the ulnaris almost follows the tendinous portion down to its insertion, the L-shaped incision provides ample exposure so that the tendon can be stripped free of its muscle attachment to a point opposite the junction of the middle and lower thirds of the forearm. The ulnaris tendon is then passed subcutaneously in an obliquely forward fashion to the dorsum of the wrist. Caution must be taken to split the antebrachial fascia at that point where the tendon becomes subcutaneous.

The flexor carpi radialis is then divided just proximal to the anterior transverse carpal ligament. At the junction of the lower and middle thirds of the forearm, it is picked up again and passed subcutaneously and obliquely forward to the dorsum of the wrist with a curved Kelley clamp. Great care should be taken to avoid twist-

the anterior carpal ligament and the long arm of the "L" running parallel and just

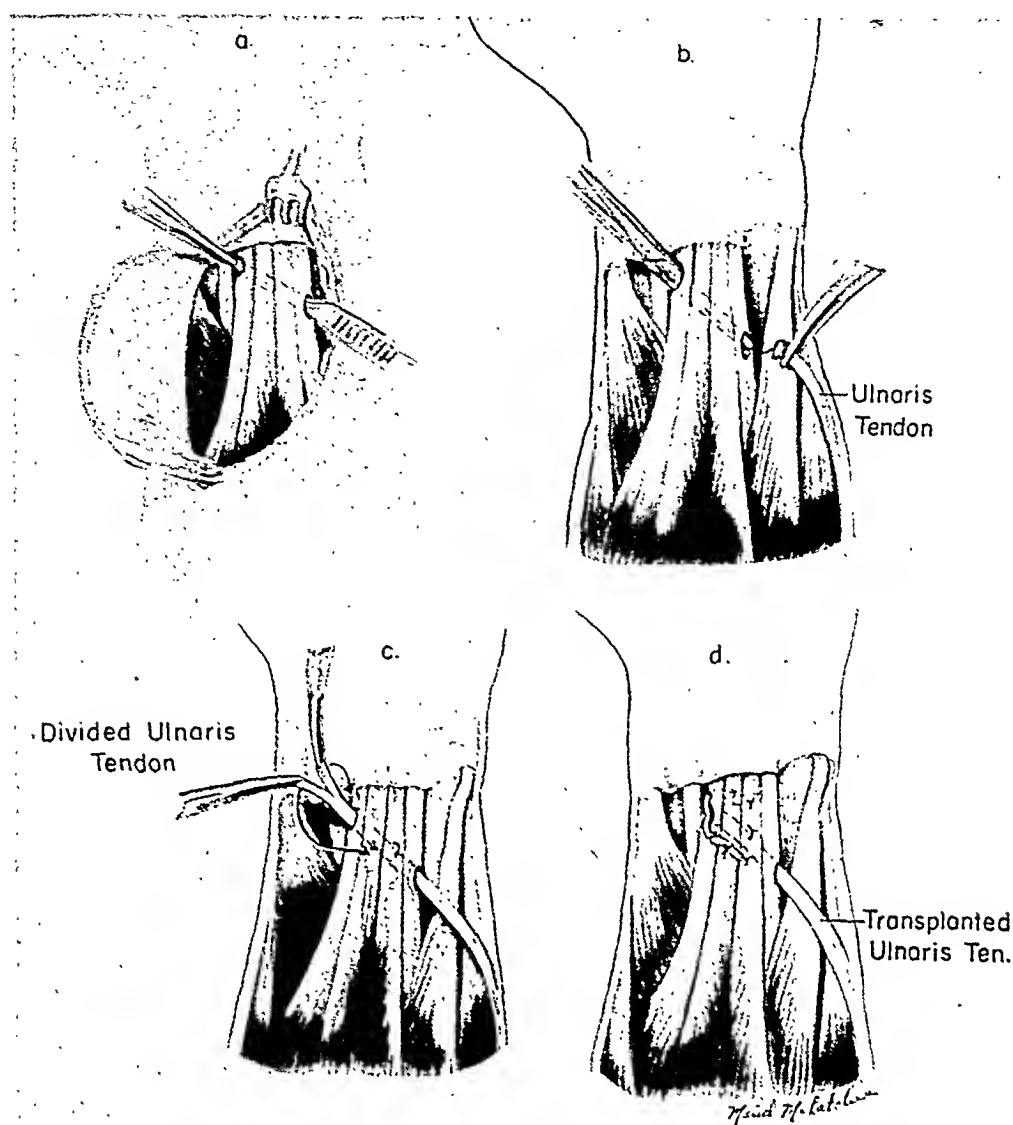


FIG. 5. A to D, the step by step procedure to secure the flexor carpi ulnaris to the common extensor tendon group of the fingers.

ing the tendon on itself in its passage from the volar to the dorsal aspect of the forearm, and the tendon must be external throughout its entirely extent to the antebrachial fascia to obtain a good functional result. At that point where the flexor carpi radialis is delivered superficial to the fascia, it is best to cut back the fascia 2 or 3 cm. as the tendon is prone to adhere at this point.

With the wrist still in its "cock-up" position, the radialis is then passed through the tendons of the abductor pollicis longus, the extensor pollicis brevis and the extensor pollicis longus in that order. Ascertaining a proper degree of tension, that part of the radialis passing through these tendons is scarified and transfixed at this point with No. 80 cotton. The end of the radialis can

then be split longitudinally and its split tails interwoven back through the three tendons named above to make the junction more secure. In like fashion, the ulnaris is passed through the extensor communis group to the second, third, fourth and fifth fingers, as illustrated in Figures 4A, B and C.

Figure 5A to D illustrate step by step the procedure to be followed to bring the flexor carpi ulnaris through the common extensor bundle.

Following this procedure, great pains must be taken to keep the wrist dorsiflexed at a 30 degree angle until the plaster has been applied. Lieutenant Colonel Rafe Nelson Hatt has circumvented this obstacle in the following manner: Once the flexor carpi ulnaris and flexor carpi radialis have



FIG. 6.

FIG. 7.

FIGS. 6 and 7. Photographs of aluminum "cock-up" hand splints.

been passed subcutaneously to the dorsum of the wrist, the subcutaneous tissues and the L-shaped skin incision are approximated with No. 80 cotton and dressed. The hand is then maintained in its proper "cock-up" position by securing an auto-claved aluminum 30 degree cock-up splint to the volar aspect of the hand and forearm. Prior to applying the splint, it is best to pad it lightly with sterile sheet wadding. This splint is illustrated in Figures 6 and 7.

The splint is maintained in position by securing it to the extremity with a roll of sterile gauze. This splint securely holds the hand at the proper angle of dorsiflexion and releases a pair of additional hands for the completion of the operation. Once the tendons have been transfixed and the dorsal skin incision approximated and dressed, the entire forearm and hand is then wrapped with gauze roll without disturbing the previously applied splint. In this manner the wrist, fingers and thumb are completely immobilized at the correct angle of dorsiflexion without danger of disturbing the tendinous junctions. The splint is removed at the end of six weeks and exercises instituted. It should not be used as a night splint thereafter, but rather a simple type of anterior cock-up splint which does not include the thumb and fingers and extends down only to the distal palmar crease.

If a plaster cast has been used postoperatively for immobilization of the forearm, hand and fingers, it likewise is removed after a lapse of six weeks. Anterior splints

should be maintained until the patient is able to keep his hand in a dorsiflexed position without artificial aid. Physiotherapy is instituted during the fifth postoperative week. During the following three or four weeks it is best that a cock-up splint be worn at night.

#### ULNA NERVE PALSY

Injury to the motor component of the ulna nerve in the wrist results in a claw hand type of deformity in that the two medial lumbrical muscles supplied by the ulna are paralyzed. As a result the proximal phalanges of the ring and little fingers cannot be flexed at the same time that the two distal phalanges are extended. It is a well known fact that following repair, the ulna nerve regenerates very slowly. Its recovery after injury is far more time-consuming than that of the radial nerve (which regenerates rapidly) or the median nerve.

As in cases of radial nerve injury, the ulnar should be first explored and primary end-to-end anastomosis with fine tantulum wire performed, if possible. A waiting period of four months following repair without any signs of regeneration is sufficient to warrant tendon transfer.

In a certain few selected cases in which the patients themselves have maintained supple metacarpophalangeal and interphalangeal joints in the ring and little fingers, we have adopted the following procedure:

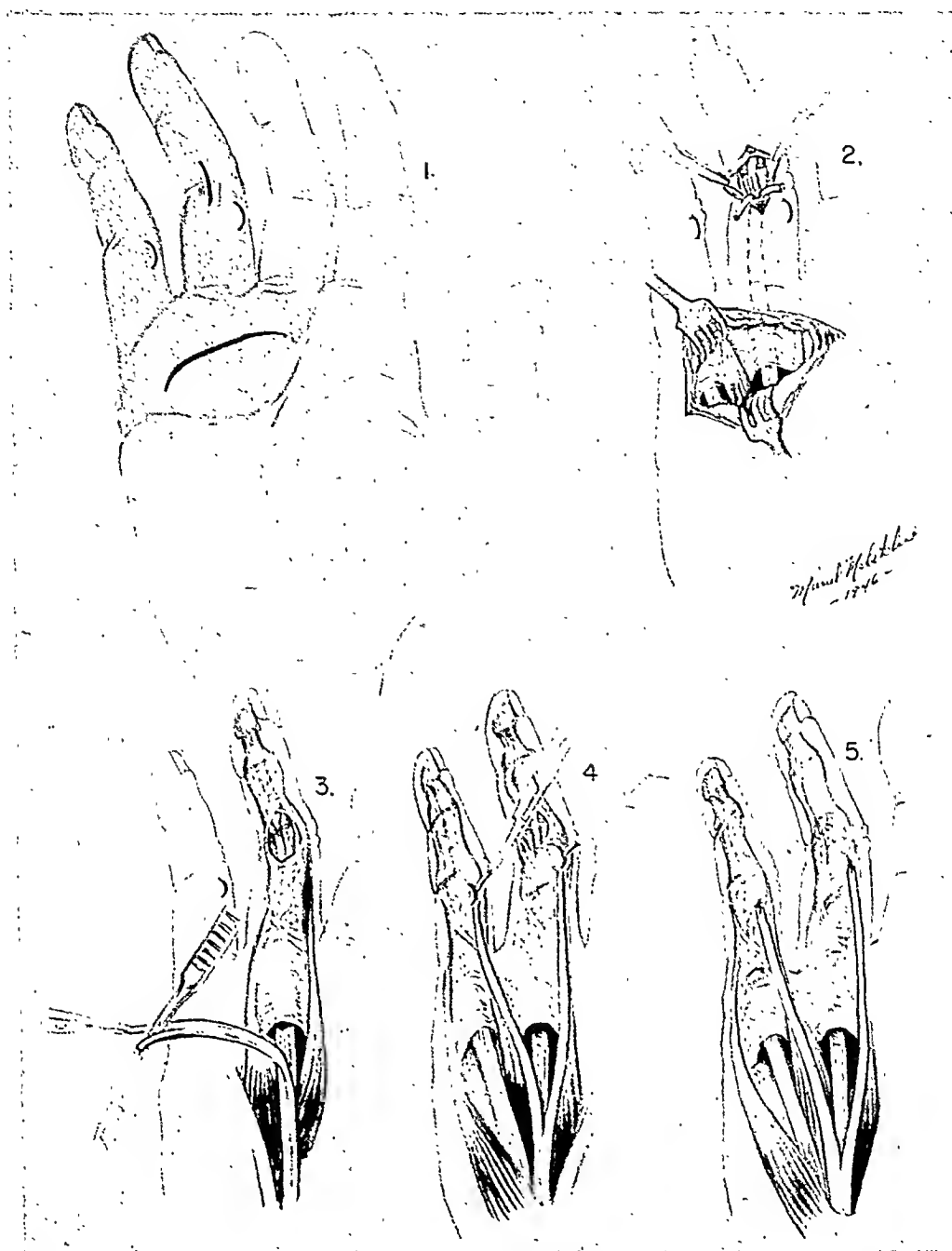


FIG. 8. A diagrammatic representation of the method of transplanting the split sublimis tendon of the ring finger to the dorsal aponeuroses of the ring and little fingers.

A small curved palmar incision is made exposing the sublimis tendon of the ring finger. Two other small incisions are made on the radial aspect of the ring and little fingers. On the ring finger, the sublimis tendon is severed opposite the proximal interphalangeal joint, the commissure cut and the sublimis tendon withdrawn through the palm. The two divisions are then separated proximally and one division passed through each lumbrical canal to the radial aspect of the ring and little fingers. The dorsal

aponeurosis is scarified as is the sublimis tendon slip. Using 35-gauge steel wire, the divisions are then attached to the dorsal aponeurosis with a small "pull-out" type of wire via the Bunnell technic. Postoperatively, the hand is encased in plaster with the fingers straight and the wrist flexed for a period of three weeks. Figure 8 visualizes the step-by-step procedure in transplanting the sublimis.

Although this arrangement of tendons cannot be explained adequately on a physi-



FIG. 9. A hand in which there is typical inability to extend the ring and little fingers because of severe damage to the ulnar nerve at the wrist joint.



FIG. 10. FIG. 11.  
FIGS. 10 and 11. The range of motion possible during the eighth postoperative week in the patient described in Figure 9.

ologic basis, i.e., using a flexor of the finger for extension, the results have been most gratifying. Within three or four weeks following the removal of plaster, the muscle groups in the digits have had enough time for re-education so that the function of the sublimis does not "check-rein" that of the profundus. Thus flexion power of the ring and fifth fingers have been sacrificed to some degree with this interchange; but instead of two useless digits which would usually be amputated, a very satisfactory hand results.

Figure 9 represents a hand in which there is typical inability to extend the ring and little fingers because of severe damage to the ulnar nerve at the wrist joint. A primary end-to-end anastomosis had been done seven months prior to tendon transfer. The patient fortunately has maintained here metacarpophalangeal and interphalangeal joints by daily passive exercises.

Figures 10 and 11 represent the range of motion possible during the eighth postoperative week in the patient described in Figure 9.

#### CONCLUSION

The technic followed at this Army installation for the treatment of ulnar and radial nerve palsy have been described. The cases in which tendon transfer for ulnar palsy has been carried out were exceedingly small in number, but the results seem to justify this report on its value. Tendon transfer for radial palsy is not a new procedure, having been resorted to frequently during World War I. However, a few of the pitfalls resulting in poor function have been pointed out.

The non-traumatic causes of dropped-wrist deformity include infantile paralysis, ischemic contracture and spastic paralysis. Previous reports indicate the value of tendon transplants for these conditions. The hand is easily held up against the force of gravity; and although power of extension is not as great as prior to injury, the utility of this extremity is great.

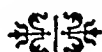
Following tendon transfer, a definite massed extension in the radial type of injury or massed flexion of the ring and fifth fingers in the ulnar type of injury results. Nevertheless, the patient soon learns to ac-

commodate for this massed action and he adapts the motions of his hand accordingly.

The authors are deeply indebted to Dr. Herbert D. Adams for advice and suggestions. The drawings in this paper were executed by Miss Muriel McLatchie, medical artist of the Massachusetts General Hospital.

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THERE are five major fascial spaces in the hand in which pus may accumulate. They are the dorsal subcutaneous space, the dorsal subaponeurotic space, the thenar space, the middle palmar space, and the web spaces between the bases of the fingers.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# ULTRAVIOLET BLOOD IRRADIATION TREATMENT OF PELVIC CELLULITIS

KNOTT METHOD

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LINCOLN, NEBRASKA

**P**ELVIC cellulitis, chronic pelvic infection or pelvic inflammatory disease constitutes the most common and persistent complaint for which women consult their doctors. These cases range from the mild inflammatory condition with dysmenorrhea to the serious surgical diseases of massive inflammatory processes involving all of the pelvic structures. The great majority of these cases are non-gonorrheal in origin and are of a mixed infection, and a high percentage of these cases have never had gonorrhea. To a great extent the infection in the pelvis in these cases is hematogenous in origin.

Pelvic cellulitis constitutes one of the diseases that is due to the inability of the host to keep out or to destroy the invading organisms which produce the disturbance. In the treatment of these conditions two principles must be kept in mind: One, to attack the invading organism and destroy it or inhibit its growth. In this process, however, nothing is usually done to stimulate the resistance of the invaded host and this lack of resistance allows the condition to develop in the first place. Second, to stimulate the resistance of the host to the point where it destroys or inhibits the invading organisms. If treatment consists only of measures to attack invading organisms with no thought to stimulation of the host's resistance, the disease process is subject to recurrence because of the host's inability to develop sufficient defense.

Ultraviolet blood irradiation by the Knot technic as approved by the American Blood Irradiation Society is the most important treatment we have at the present time to stimulate the host in the process of building up resistance.

By increasing blood oxygens up to 300 per cent and by increasing the phagocytic action of the white blood cells 50 to 100 per cent, we are doing something to stimulate the individual resistance to help destroy the invading organisms. Recently, much has been done to develop drugs which will destroy or inhibit the invading organisms, but very little has been done to stimulate the individual's resistance against the infection.

Ultraviolet blood irradiation treatments are usually given at intervals of two to four weeks, and patients require two, four or six treatments, sometimes more. In severe cases treatments may be given more frequently as indicated, and in chronic cases treatments may be given at intervals one, two or three months apart for a period of time.

Since June, 1944, we have treated 631 patients with this condition with such unusually gratifying results that we believe they are worth reporting. These are classified as very severe, 220 cases or 35 per cent; moderately severe, 238 cases, or 38 per cent; and mild, 173 cases or 27 per cent. At the present time we do not operate upon any patient with a pelvic disorder unless there is an abscess, tumor, cyst or other organic condition which is not purely inflammatory. Almost all massive inflammatory diseases will subside and recover completely without surgical intervention, and in many cases the massive inflammatory process was so extensive that it seemed impossible for them to disappear completely without surgical intervention. A large number of the patients treated had massive inflammatory disease, many had been persistent for years and had been



under treatment of various types for prolonged periods. It is gratifying to see patients improve rapidly under ultraviolet blood irradiation and return to normal, with the massive inflammatory process entirely disappearing. The recovery of these patients more nearly approaches complete recovery than with any other treatment. The pain and tenderness subsided in most cases in two to ten days, and the swelling and massive induration disappeared gradually from the first few days. In most cases in four to eight weeks the swelling and tenderness had entirely disappeared and the organs were back to normal.

In all of our serious diseases of the pelvis in which hysterectomy or other extensive surgical procedure is carried out, ultraviolet blood irradiation is given preoperatively and postoperatively. It is found that those patients withstand this surgery comparatively easily. There are very few postoperative complications and patients have a rapid and smooth recovery; few have postoperative ileus and peritonitis. Patients move about easily, require less opiate and have very little vomiting. The bowel maintains its tone much better and gas is seldom a problem. The mortality rate is greatly reduced and morbidity is reduced about 50 per cent compared to cases in which operation is performed without this treatment.

During the past twenty-five years we have used every means at our command to clear up pelvic inflammatory conditions without surgical removal of the organs, and have found ultraviolet blood irradiation by far the most effective in both acute and chronic cases. The treatment is easy to carry out and so well accepted by the patients that it is a very welcome relief to them.

In the series the first group consists of 220 cases of very severe chronic non-gonorrheal pelvic cellulitis with massive swelling, tenderness, pain, etc. The duration of complaint ranged from several months to many years. All had had recurrent attacks and many had been operated on. Of these pa-

tients, 174 or 79 per cent, have been completely relieved of all symptoms and the pelvic organs have returned to normal condition, size and position, and have developed a feeling of well being which they have not had for years. This group received no other treatment. Twenty-four patients or 11 per cent were improved, and twenty-two or 10 per cent were operated upon. Of the twenty-two operations, ovarian cysts, fibroids and/or definite abscess formations were the conditions found at operation.

The second group consists of 238 cases of moderately severe pelvic inflammatory disease as compared to the very severe group above. On examination these patients revealed marked swelling and tenderness of the pelvic structures. All had been complaining for from several months to several years with recurrent attacks of moderate or severe proportions. Some of these patients had been operated upon and some of the pelvic structures removed for this pelvic inflammatory disease. After ultraviolet blood irradiation therapy 191 or 80 per cent were entirely relieved of symptoms and the pelvic organs returned to normal. There was entire absence of pain, tenderness and swelling, and function of organs returned to normal. Twenty-four or 10 per cent were markedly improved but were not entirely relieved of all symptoms and continued to have some tenderness. Twenty-three or 10 per cent did not continue treatment and the result is not known.

The third group consisted of 174 patients with chronic, mild, pelvic infection with severe dysmenorrhea. On examination these patients all revealed very tender pelvic organs but without palpable masses. A large number of cases were young women, many of them unmarried, who had complained of severe dysmenorrhea for many years. The findings in these cases are compared to a large number of normal patients examined in whom no tenderness was found and no dysmenorrhea was present. After adequate ultraviolet blood irradiation therapy 151 or 87 per cent were entirely relieved of all symptoms. Dysmenorrhea entirely

disappeared and on examination they were found not to have any tenderness or evidence of the pre-existing inflammation. The feeling of well being and improvement generally was very marked. Seventeen patients of this group were improved and six did not return for treatment.

In this series there were seventeen cases of sterility. The duration ranged from two years to many years. All these patients had chronic inflammatory disease of moderate severity. They became pregnant after ultraviolet blood irradiation therapy and have gone through or are going through a normal pregnancy.

There were also five cases of threatened abortion in patients with pelvic cellulitis. The abortion had progressed to a point of regular frequent pains, heavy bleeding, and seemed inevitable in each case. All these symptoms subsided promptly with ultraviolet blood irradiation treatment, and the patients continued to full term and normal delivery.

#### CASE HISTORIES

The following are a few examples of patients treated:

Mrs. M. E., age thirty-three, married, the mother of two children, was operated upon five years before for extensive salpingo-oophoritis without suppuration in the left tube and ovary. The patient returned with an identical mass about the size of an orange in the right side of the pelvis. She had been under treatment for several months. There was marked tenderness, pain and temperature, with pain radiating down the right leg. After the first ultraviolet blood irradiation the patient was relieved of pain in forty-eight hours. Following this, treatments were given and in six weeks the mass had entirely disappeared. She has been watched for two and one-half years without recurrence of this mass.

Mrs. C. W., age forty-six, had had severe dysmenorrhea as a young girl, was married, had three children, and had also had four spontaneous miscarriages. During her entire menstrual life she had had pelvic disease. Marital relations were very painful, and the

patient suffered intensely each month. Examination revealed a large tender mass filling the pelvis and involving all structures. After six weeks on ultraviolet blood irradiation treatment the massive inflammation had disappeared. Tenderness disappeared and marital relations were not painful. The patient stated that she felt better than she had for as long as she could remember.

Three young girls, unmarried, fifteen, seventeen and eighteen years of age, respectively, came in for examination with acute pain in the pelvis. Bimanual examination by rectal method revealed a very tender mass in the ovary about 6 cm. in diameter. All three had a very small introitus, indicating no sexual relations. After the first ultraviolet blood irradiation treatment each patient was relieved of pain in twenty-four to forty-eight hours, and in about two weeks the masses had entirely disappeared. The patients have been followed and no recurrence of the condition has appeared.

One patient with threatened abortion at six months' pregnancy who had been in the hospital for several weeks, had reached the point of heavy bleeding and regular pains every five minutes. Within twelve hours after the first ultraviolet blood irradiation treatment all pains ceased and bleeding stopped in thirty-six hours. This patient had no more difficulty, went through to full term and delivered a normal baby. She was given three ultraviolet blood irradiation treatments.

#### CONCLUSION

During twenty-five years of practice I have never found any treatment for chronic pelvic cellulitis that compares with ultraviolet blood irradiation by the Knott technic as approved by the American Blood Irradiation Society. The relief to patients is very marked and the return to normal of the pelvic structures is very interesting. The general improvement of the patient is also remarkable. By this method of treatment it is possible not only to relieve a large percentage of patients with acute and chronic pelvic cellulitis, but it is also possible to avoid surgical removal of structures unless there is a definite cyst, tumor or organic disease other than inflammatory.

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# COMBINED APPENDECTOMY AND INGUINAL HERNIOTOMY\*

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**A** TECHNIC thought to be original was first used by one of us (W. H. M.) about ten years ago for the performance of an appendectomy through the same incision as an inguinal herniotomy. Over a period of years the uses of this operation have expanded so that now it has been found advantageous in the repair of difficult hernias on the left side as well as on the right.

The advantages claimed for this operation are the following: (1) The appendix may be removed through an incision of adequate size which may be enlarged if necessary. (2) The finger may be inserted through the internal ring from within the abdomen into the hernial sac facilitating its dissection. (3) The transversalis fascia in the region of the internal ring is not disturbed, stretched or incised in efforts to perform an appendectomy through this opening. (4) The accurate placing of sutures in the transversalis fascia, especially in large thinned out, direct hernias is facilitated by a finger or fingers inside the abdomen when placing sutures. (5) Abdominal contents and bladder may be held away from the region of operation when placing sutures. This allows full bites of tissue to be taken without danger of visceral puncture or injury. (6) In large, adherent or sliding hernias on either right or left sides, a muscle splitting incision which allows the fingers to be placed in the abdominal cavity greatly facilitates the identification and isolation of the sac.

A recent search of the literature reveals but one operation somewhat similar, that of Torek. His operation, described in 1906, incises the aponeurosis of the external oblique muscle from the external ring to near the anterior superior spine. Herniotomy is continued in the routine manner to

the completion of the sac ligation. The hernia operation is then interrupted and the appendectomy performed through a muscle splitting incision in the usual site. The hernial closure is then finished. No mention is made of intra-abdominal manipulations other than appendectomy. Review of the literature both on general surgery and hernia mention only appendectomy through the internal ring or in cases in which the appendix occupies the sac.

## TECHNIC

For unilateral hernia the skin incision parallels the inguinal (Poupart's) ligament, about 2 cm. above the same. This incision extends from a point medial to the anterior superior spine of the ilium to the region of the external ring. In bilateral hernia an incision of the Pfannenstiel type is used.

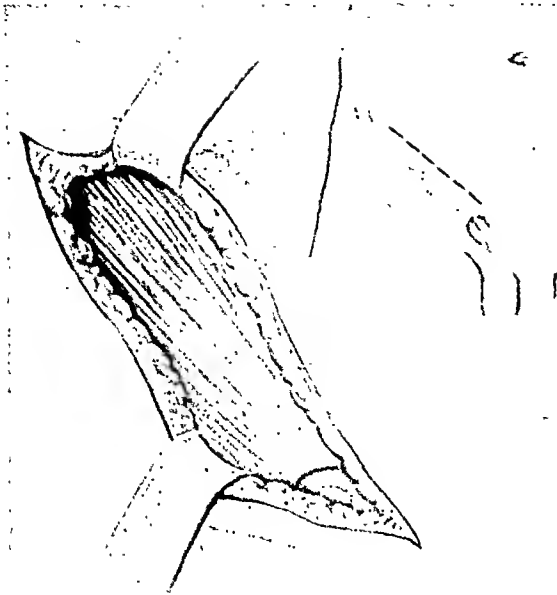
The skin incision is carried down through the superficial fascia and Scarpa's fascia to the aponeurosis of the external oblique muscle. In the Pfannenstiel incision the Scarpa layer need not be incised across the midline rectus area between the external rings.

The aponeurosis of the external oblique muscle is split in the direction of its fibers by incision of the intercrural fibers, from the upper border of the external ring to a point near the anterior superior spine of the ilium. The lower leaf, usually 2 to 3 cm. in width, is used in repair. A narrow strip of the lower edge of the upper leaf is left attached at its medial end. This may be used in repair by the fascial strip method.

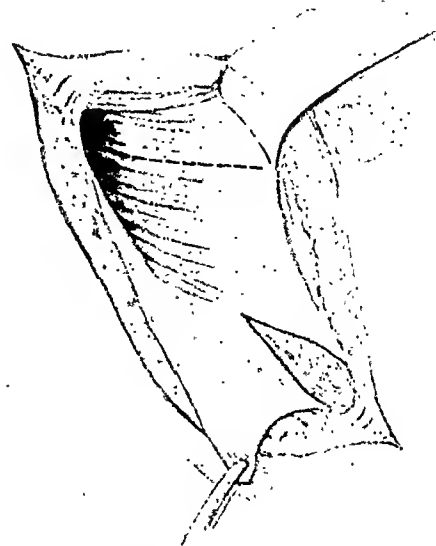
The aponeurosis is dissected free from the sac and cord with care being used to avoid injury to the ilioinguinal nerve.

A retractor is placed beneath the outer third of the upper edge of the external oblique aponeurosis and retracted upward.

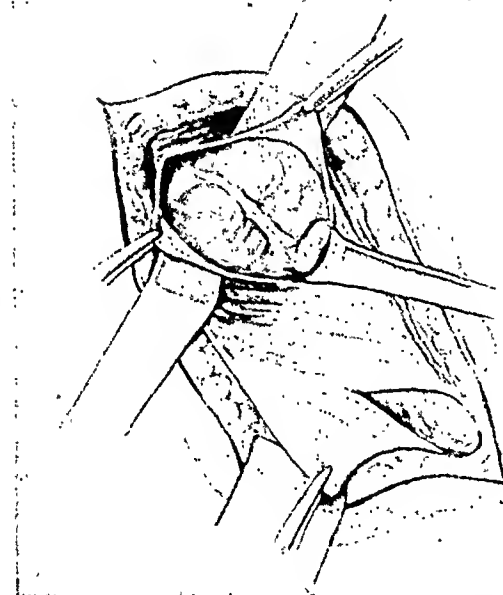
\* From the Myers Clinic, Coal Valley, Ill.



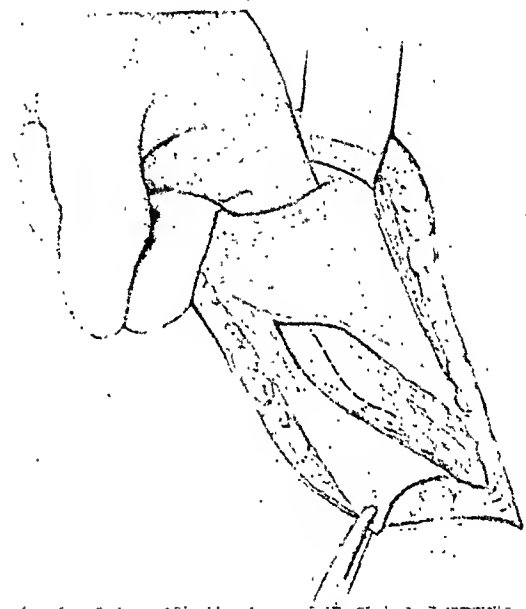
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FIG. 1. Upper right, line of incision in unilateral operation; at left, skin and superficial fascia incised; aponeurosis of external oblique muscle exposed.

FIG. 3. Cecum and appendix delivered through muscle splitting incision in internal oblique and transversalis muscles.

FIG. 2. Aponeurosis of external oblique muscle incised and retracted. Retractor under lateral third of upper edge pulls aponeurosis upward exposing usual site of muscle splitting McBurney incision.

FIG. 4. The appendectomy having been completed, the cecum is returned to the abdomen. The left index finger is inserted into the sac from within the abdomen, facilitating its identification and dissection. Other types of sacs, direct, femoral, obturator or combinations thereof may be easily palpated.

The fibers of the internal oblique muscle are exposed and a typical muscle-splitting appendectomy incision is made in the usual site. Should unusual difficulties attend appendectomy this incision may be extended medially and downward along the rectus sheath without jeopardizing the subsequent hernial repair.

When appendectomy has been performed, the index finger of the left hand is

inserted into the internal ring and sac from within the abdomen. This facilitates identification and dissection of the sac. The sac contents are reduced and the sac is ligated high with chromic catgut. The possibility of including abdominal viscera is negligible

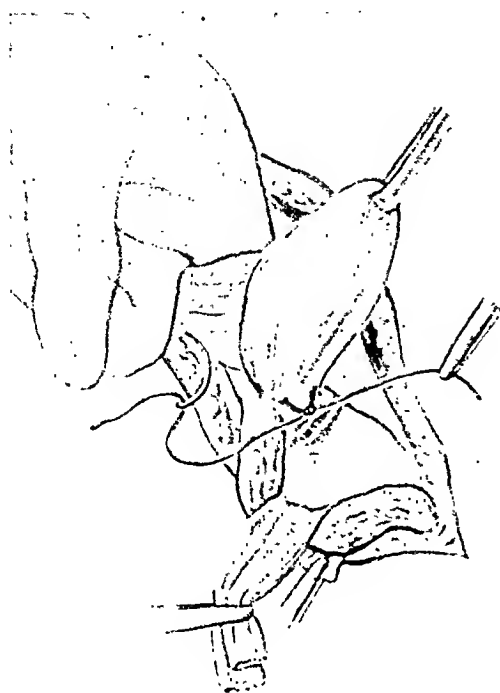


FIG. 5. The sac is dissected free and contents emptied. Adhesions about the neck or inside the sac are attacked from within the abdomen or from within the sac as necessity may require. Ligation is facilitated and made safer by finger or fingers beneath the area.

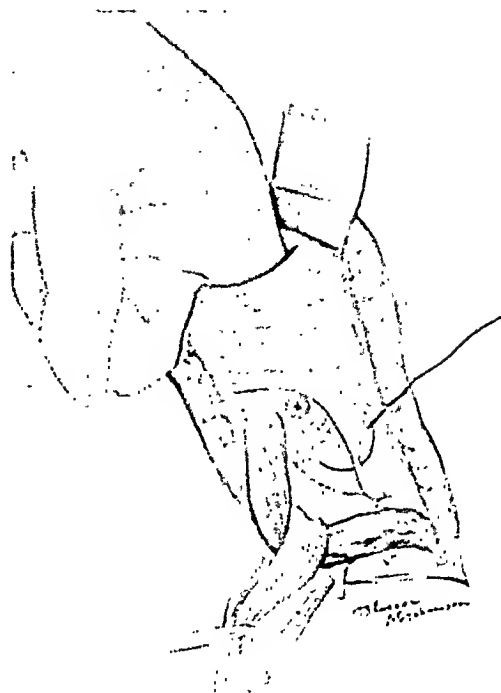


FIG. 6. With the fingers inside the abdomen full bites of tissue may be taken in placing of sutures without danger of including other structures such as bladder, intestines or femoral vessels. The first two interrupted wire or fascial strip sutures placed through conjoined tendon, transversalis fascia, Cooper's and the lacunar ligaments medial to the femoral vessels closing the femoral canal are especially facilitated.

as the finger below keeps the viscera from being tied.

Not only indirect sacs but the other types such as direct, the combination or pantaloon type and femoral may be more easily identified. An overlooked direct or femoral sac may be counted as a recurrence a few months or years later. The accurate dissection of the direct sacs and the oft present bladder is facilitated by the intra-abdominal palpating finger. Finding all sacs, their thorough dissection from surrounding structures, and closure of the weakened areas by accurate suturing possible by this means is the best of insurance against recurrence.

In repair of inguinal hernia it has been demonstrated that well placed sutures from the transversalis fascia to the inguinal ligament are all important. Sutures of muscle to inguinal ligament are easily done without danger of passing the needle through the peritoneum and inadvertently including bowel or bladder but the results

of muscle fascia unions are questionable in many cases. Sutures in the more deeply placed and often poorly defined transversalis fascia are another matter. Here the fingers beneath the area being repaired aid immeasurably in the quick accurate dissection, isolation of fascial edges and placing of sutures with full bites of tissue without danger of visceral damage.

Our preference in suture material is stainless steel wire. This material is strong, is non-absorbable, does not set up foreign body reaction in the tissues and the technique is fairly easily mastered. Interrupted sutures with square knots are used throughout. The wires are cut as close to the knot as possible and at right angles to the suture. The sac and the peritoneum are closed with No. 1 chromic catgut to eliminate the possibility of a broken wire or knot causing peritoneal irritation or visceral injury. No.

32 wire is used throughout with the exception of Scarpa's fascia and skin where No. 36 is used. No retention sutures are required in most cases.

There is a notable absence of wound swelling and induration with the use of wire, probably due to the negligible amount of foreign body reaction. There is also a notable absence of postoperative pain and collection of serum, with resulting wound infections. Should a wire-sutured wound become infected it will heal well after drainage without sutures being extracted. This is in contradistinction to other non-absorbable sutures. Where cotton or silk are used and the wound subsequently becomes infected, they may be fished out of sinuses for a protracted period.

Steel sutures give a feeling of security that is well founded. We have never observed any wound complication or rupture following its use in over 600 cases of hernia and abdominal section. Hernia cases are allowed out of bed to void if necessary the day of operation. Older patients are encouraged to get up in a chair the day after operation. Hernia cases are hospitalized for one week only.

Our preference in repair of indirect inguinal hernia is closure by a modified Bassinni method. The transversalis fascia is closed by interrupted wire sutures from the spine of the pubis to beyond the internal ring. The sutures medial to the femoral vein include a bit of periosteum of the pubis, Cooper's ligament, as well as the shelving portion of Poupart's ligament and the lacunar ligament closing the femoral canal. This area is a site of postoperative recurrence and must be closed.

Where the tissues are thinned out, a fascial strip from the thigh or from the lower edge of the upper leaf of the external oblique aponeurosis is employed. In the latter case a strip about .5 cm. wide is dissected free leaving the medial end attached. A Masson fascia needle is affixed to the lateral end. This strip is used to suture transversalis fascia and oblique muscle to Poupart's ligament by a continuous suture

from the pubis to the internal ring. This technic was observed at Rochester, Minnesota, in 1936 at an operation performed by Dr. C. W. Mayo. It has since been described by others.

In direct hernia our preference is to bring the cord out directly through the abdominal wall at the internal ring. A fairly snug ring is fashioned with interrupted sutures of the aponeurosis to Poupart's ligament after closure of the deeper layers as outlined under indirect hernia. The entire region from the emergence of the cord to the spine of the pubis is then tightly closed in layers with interrupted sutures of No. 32 wire.

The muscle splitting incision is sutured in the usual manner before closure of the external oblique aponeurosis. Special care must be used in the closure of peritoneum and transversalis fascia in a muscle splitting appendectomy incision. Failure in fascial closure here may weaken the lower inguinal transversalis fascia, predisposing to inguinal hernia recurrence.

Scarpa's fascia is sewed with interrupted sutures of No. 36 wire. The skin is sutured with interrupted or continuous No. 36 wire. No retention sutures are usually needed. The skin sutures may be removed in seven to ten days. No superficial irritation is observed even if they are not removed for a prolonged period.

A similar muscle splitting incision may be used on the left side in difficult hernias such as those with adherent sacs or of the sliding types. With the use of the fingers on the peritoneal side and inside the sac, a quick accurate dissection may be made and repair of the wall facilitated.

#### CONCLUSIONS

An operation for combined appendectomy and inguinal herniotomy is presented.

The following advantages are claimed:

- (1) Appendectomy may be performed through an adequate incision and in the usual site.
- (2) With the finger inside the sac it may be quickly identified and dissected.
- (3) The sac may be ligated and the

transversalis fascia safely and thoroughly sutured without danger of visceral damage by placing the fingers beneath the area being sutured. (4) Large, adherent or sliding hernias on either right or left sides, may be more safely, rapidly and accurately

dissected and repaired with the use of the approach from the abdominal side.

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AN unnecessary appendectomy should not be done during an abdominal or pelvic operation which probably will be followed by some oozing of blood into the peritoneal cavity. A sump drain is routinely advisable if there is a possibility of postoperative oozing both to indicate the presence and amount of oozing and to keep the cavity free from blood and exudate.

From "Principles and Practice of Surgery," by W. Wayne Babcock (Lea & Febiger).



# COMPARATIVE STUDY OF CHEMOTHERAPIES IN THE SURGERY OF PILONIDAL SINUS\*

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THE great preponderance of literature on pilonidal sinus deals with new surgical methods of closing the wound remaining after the sinus has been excised. The multiplicity of these descriptions testifies that surgery of the intergluteal fold is still far from satisfactory. Since so much has been written on surgical technic and so very little upon the significance of chemotherapy in the healing of the post-excisional pilonidal wound, the present study has been devoted to the latter problem.

From October, 1942, to October, 1945, the authors in treating 129 pilonidal sinuses, applied at different times four different combinations of chemotherapy, namely: (1) no chemotherapy; (2) sulfonamides only; (3) penicillin locally and sulfadiazine by mouth; (4) penicillin, medium doses parenterally, and (5) penicillin, large doses parenterally. Unfortunately, these were applied in successive periods and not in strict rotation, thus losing much of their comparative value. The first nineteen pilonidal sinuses were dealt with by excision and local wound packing to allow healing by granulation. The remaining 110 sinuses in which the excision wound was primarily closed form the basis of our studies. With the possible exception of two or three cases early in our experience, all the 110 cases were active symptomatic pilonidal sinuses and not innocent little lesions picked up in routine physical examination.

## PRE- AND POSTOPERATIVE CARE

The usual incision and drainage of acute abscesses and daily sitz baths for a week or two for grossly infected cases before

excising the sinus tracts was carried out. Surgery in each case was delayed until the wounds appeared "surgically clean" or nearly so, a period varying from twelve to thirty days.

When oral sulfadiazine was to be used, it was nearly always started twenty-four to forty-eight hours or more before surgery, 2 Gm. every four hours for several doses, then 1 Gm. every four hours. This was continued for five to seven days after operation with an occasional intravenous injection of 5 Gm. of sodium sulfadiazine at the time of operation.

Parenteral penicillin, when used, was usually started three to seven days pre-operatively, but occasionally it was not begun until the time of operation. In nine of the twenty-two patients receiving average doses of penicillin (20,000 to 25,000 units every three hours) treatment started at operation with three failures (30 per cent), whereas of the remaining thirteen patients pretreated for two to seven days there were seven failures (54 per cent). Although these few results are contrary to expectation, it is our clinical impression that a period of pretreatment definitely improves the prophylactic value of penicillin. Injections were continued for from five to ten days or more after operation.

Postoperatively the patient was placed on a constipating routine for five days and was kept in bed for eight to twelve days. No set policy as to the position of the patient in bed was followed. Care was exercised to keep each wound clean and dry at all times.

## OPERATIVE TECHNIC

It appears that the many recorded methods of closing a pilonidal excision

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wound, some of which are quite ingenious, all approach by different routes certain common objectives: hemostasis, obliteration of dead space and closure without tension. Our method of achieving this was as simple as possible and certainly not original. With a few exceptions it took the following pattern:

1. The cyst or sinus was excised with as little excess tissue as possible and the dissection was carried down to the presacral fascia. The cysts are usually found to be surprisingly small and any accessory or branching sinuses lie plainly defined within the superficial fat tissue. In our experience recurrences or failures to heal are due not to leaving behind some minute diverticulum, real or imagined, but rather to local mechanical difficulties of closure, infection or both.

2. The wound walls were undermined at the level of, or just deep to, the thin fascia covering the gluteal muscles. This allowed their approximation with as little tension as possible with interrupted stitches which caught the mobilized base of each wall and the underlying presacral fascia.

3. One or more additional tiers of buried sutures were placed to "build up" accurately the wound and obliterate dead space.

4. Fine stainless steel stay sutures were passed through all layers, including the underlying fascia. As the final step of the operation, these were tied snugly over a single roll of mechanics waste, placed over the suture line. We have come to prefer this simple through-and-through stitch to Ferguson's<sup>1</sup> on-end mattress stay suture tied over two longitudinal rolls on either side of the wound, which in our hands was prone to cause small areas of skin slough.

5. Meticulous technic and the finest possible, non-absorbable suture material were used throughout.

6. Local chemotherapy, when used, consisted of either a light dusting with sulfanilamide crystals or injection into the walls and floor of the wound through a hypodermic needle of 30 to 60 cc. of penicil-

lin solution, 250 to 500 units per cc. This latter serves a two-fold purpose: It localizes a high concentration of penicillin in the immediate operative field and also creates an artificial local edema later to be replaced by that from operative trauma. Sutures placed in such preswollen tissue should be less likely to cut through.

#### ANALYSIS OF FACTORS UNFAVORABLE TO WOUND HEALING

Unfortunately this study of chemotherapy was not conceived in its present form until nearly its termination. As a consequence the various chemotherapies had been used in successive periods instead of in scientific rotation. In an attempt to correct in part for this in our final evaluation of the different methods, all the pilonidal sinuses have been analyzed as to their qualities unfavorable to healing. The following four seemed to us the most important: (1) large size and/or complexity of sinus which would render wound closure mechanically difficult; (2) clinically detectible infection. This necessarily arbitrary classification included all lesions showing the maximal clinical evidence of infection, although actually small, that were compatible with primary wound closure. These lesions might show slight induration or tenderness or more than minimal exudate as compared to simple sinuses showing no infection or a barely noticeable amount; (3) history of abscess formation with or without incision and drainage within the past one to six months; (4) recurrent pilonidal sinus or one still unhealed following a previous unsuccessful attempt at closure.

The percentage incidence of the above factors among the five different therapeutic groups will give at least a rough comparison of the handicaps or hindrances to healing that had to be combatted in each group. These are shown in Table 1. It will be seen from the table that the sinuses estimated as the least susceptible to closure were those treated by penicillin in "medium" or in "large" doses.

The four factors unfavorable to healing were further analyzed, as shown in Table II, to determine their percentage incidence among wounds successfully closed and those in which closure failed. It is interesting to note that size and complexity of

was more common among the successful than among the unsuccessful closures.

#### WOUND CULTURES

Cultures of wounds at time of closure, unfortunately, were not consistently taken. They were recorded twenty-one times

TABLE I

INCIDENCE BY PER CENT OF UNFAVORABLE FACTORS IN THE FIVE THERAPEUTIC GROUPS

Chemotherapeutic Group	Large Sinuses, Per Cent	Clinically Detectible Infection, Per Cent	Abscess within 6 Mo., Per Cent	Recurrent Lesions, Per Cent
No chemotherapy.....	17	33	21	21
Sulfanilamide only.....	17	11	56	22
Penicillin locally and sulfadiazine by mouth.	3	25	30	20
Penicillin in medium dosage.....	32	41	70	36
Penicillin in large dosage.	43	7	50	50

TABLE II

INCIDENCE BY PER CENT OF UNFAVORABLE FACTORS AMONG SUCCESSFUL AND UNSUCCESSFUL CLOSURES IN THIS SERIES

Outcome of Wound Closure	Large Sinuses, Per Cent	Clinically Detectible Infection, Per Cent	History of Abscess		Recurrent Lesions, Per Cent
			Within 30 Da., Per Cent	Within 6 Mo., Per Cent	
Per primam or subtotal.....	10	51	33	43	25
Failure.....	46	73	19	38	38

sinuses and the clinical appearance of slight infection at the time of closure were much less common among the successful closures than among the failures; while the other two factors, history of abscess within the previous month and recurrence of sinus, seemed not definitely to predispose to failure of a given closure. In fact, it will be observed that recent acute inflammation

TABLE III

CULTURES OF PILONIDAL EXCISION WOUNDS TAKEN AT OPERATION

Wound Culture	Successful Cases	Failures
Staphylococcus alone or with B. hemolytic streptococci.....	10	6
B. hemolytic streptococci.....	3	0
Microaerophilic streptococci.....	0	1
A. Arogenes.....	1	0
Citrobacter.....	1	0
Diphtheroids.....	2	1
No growth.....	4	3

among the successful cases and eleven times among the unsuccessful cases. That the type of organisms present seemed to show no particular influence on the outcome of a given closure is shown by Table III. It will also be noted that a sterile culture was found three times among the eleven failures and only four times among the twenty-one successful closures.

#### COMPARISON OF THE DIFFERENT CHEMOTHERAPEUTIC REGIMENS

Table IV shows the per cent of successful and unsuccessful primary closures of pilonidal sinus excision wounds, first when no prophylaxis was used, and then when each of the four chemotherapies was employed. The smallness of the therapeutic groups and the variability in difficulty of wound closure (Table I) prevent our accepting this analysis at its face value.

It will be seen that the most promising results of the entire series were obtained by the combined use of oral sulfadiazine and local penicillin (93.8 per cent success), even when reference to Table I reveals that these wounds were estimated as the least unfavorable of all to successful closure. The results of this therapeutic

combination seem definitely better than where no chemotherapy, or where sulfonamides alone were used. Its apparent superiority to the group receiving penicillin in large doses must be discounted by the greater unfavorability to wound closure of that group. (Table I.)

TABLE IV  
COMPARATIVE RESULTS OF DIFFERENT  
CHEMOTHERAPEUTIC GROUPS

Therapeutic Group	Total No. Cases	Per primam or Subtotal Healing*	Failures	Per Cent Success†
No chemotherapy.....	24	15	9	62.5
Sulfonamides only‡....	18	14	4	77.7
Penicillin locally sulfadiazine by mouth....	32	30	2	93.8
Penicillin in medium doses§.....	22	12	10	54.5
Penicillin in large doses  .....	14	11	3	78.6
Total cases.....	110	Average for entire series		73.4

\* By "subtotal healing" is meant per primam healing but for a small, superficial area of breakdown which has completely healed within thirty days leaving no appreciable flaw or deformity in the wound.

† Successful cases include per primam and subtotally healing wounds.

‡ Of these, fourteen received sulfadiazine by mouth only, four received local sulfanilamide only, and two received both.

§ 20,000 to 25,000 units every three hours with or without local injections at operation.

|| 40,000 to 80,000 units every three hours. Eleven received local injections at operation.

The poorest showing of the series was made by the group receiving penicillin in medium doses (54.5 per cent success), even when we take into consideration that these sinuses were the least favorable to closure, as shown in Table I. Had penicillin in medium dosage been of significant prophylactic value, the results among the twenty-two cases of this therapeutic group should have compared more favorably with the twenty-four cases which received no chemotherapy.

Although only fourteen patients received large doses of penicillin, we were impressed with the superior outcome of their wound closures as compared with the equally difficult closures in which only moderate penicillin dosages were used (78.6 per cent success compared to 54.5 per cent). Also, of the three failures in the large penicillin dosage group, one was a wound

disruption on the fourth postoperative day when the patient unduly strained his wound. In the second case, healing of a very large wound was complete but for a small and superficial area where the skin edges pulled apart because of a local defect in closure. This failed to close for over two months. The two case reports that follow suggest the value of large penicillin dosage when the usually accepted dosage appears to be inadequate.

CASE I. This twenty-six year old white private had had recurrent drainage and abscess formation in a large pilonidal sinus since 1939. He spent seventeen months overseas in various Army Hospitals under treatment, during which time four operations were performed, including three excisions, the first one followed by primary wound closure. The patient arrived at this hospital March 1, 1945, with a large undermined, secondarily infected pilonidal sinus. After a preliminary furlough and a period of local cleanliness and sitz baths, penicillin was started April 6, 1945, 25,000 units every three hours intramuscularly. On April 10th the long residual pilonidal tunnel was re-excised. Operative culture revealed *Staphylococcus albus*. Thirty cc. of penicillin solution (500 units per cc.) were injected into the walls and base of the wound with a hypodermic needle and closure was carried out in layers, using fine cotton sutures and stainless steel wire stays tied over mechanics' waste. The third postoperative day, wound cellulitis developed and the temperature rose to 101.5°F. Probing revealed only a little serum harboring *Staphylococcus aureus*. The penicillin injections were increased to 50,000 units. After a rise to 102.5°F. the following day, the temperature as well as the cellulitis rapidly subsided. When the dosage was again dropped to 25,000 units every three hours, there was a second mild return of infection, which subsided for good after three more days of the 50,000 unit doses. Per primam healing was complete April 17th, and the wound was still soundly healed when the patient was last seen following furlough a month later.

CASE II. This twenty-two year old white private, first class, first became aware of a pilonidal sinus with abscess formation October 28, 1944, while in the European Theatre. He

was transferred to a general hospital in England where, after due preparation, the sinus was twice excised and primarily closed, but with failures both times. In connection with both operations the patient received a week or more of intramuscular injections of 20,000 units of penicillin at three-hourly intervals. The soldier arrived at this hospital May 12, 1945, with a large, badly-infected, tender, draining pilonidal sinus extending down to within 2 inches of the anal verge. *Staphylococcus aureus*, non-hemolytic streptococci and diptheroids were recovered from the wound. After the initial local "clean up" period of sitz baths, penicillin was started May 24th in three-hourly intramuscular injections of 25,000 units and May 29th excision and primary wound closure was carried out exactly as described in Case 1. Thirty cc. of the 500 unit per cc. penicillin solution were injected locally into the wound walls and the parenteral dosage was increased to 40,000 units every three hours. The dosage was again raised to 60,000 units on June 1st, when slight wound cellulitis developed; dropped back to 25,000 units on June 5th when the cellulitis had subsided; again increased to 50,000 units June 6th when the local cellulitis had again made a slight appearance, and finally discontinued June 14th. The wound had healed per primam by June 10th and still remained so when last seen by us several weeks later.

A cursory review of the literature reveals that little has been written upon the rôle of chemotherapy in the surgery of pilonidal sinus. Local dusting of sulfanilamide crystals is recommended by Weeks and Young<sup>2</sup> and Camp and Polites,<sup>3</sup> while Scott<sup>4</sup> finds buffered sulfanilamide much superior to the unbuffered agent. Bartlett,<sup>5</sup> Woldenberg and Sharp,<sup>6</sup> Theis and Rusher<sup>7</sup> and Barnett<sup>8</sup> recommend oral sulfadiazine with or without local application. Barnett also believes, as we do, that local penicillin is more efficacious than local sulfanilamide. Theis and Rusher and Scott find local sulfanilamide alone little if any superior to absence of chemotherapy. The results reported by these workers range from 18 to 42 per cent failures in non-treated closures; 31 to 40 per cent failures when local sulfanilamide alone was used; 3.6 per

cent failures (in twenty-eight cases) with buffered sulfanilamide locally; and 14 to 22 per cent failures when oral sulfadiazine alone was used.

From our own clinical experience and from the analysis of Table iv, it would appear logical in most closures to use a combination of oral sulfadiazine pre- and postoperatively and local penicillin injection at operation. Then, should there be any evidence of wound cellulitis following closure, massive doses of penicillin (60,000 to 80,000 units every three hours) should be started at once and continued till resolution of infection or definite wound break down.

#### SUMMARY

1. One hundred ten primary closures of pilonidal sinus excision wounds personally performed by the authors were treated as follows:

	No. Cases
(a) No chemotherapy.....	24
(b) Sulfonamides.....	18
(c) Local penicillin combined with sulfadiazine by mouth.....	32
(d) Medium doses of parenteral penicillin.....	32
(e) Large doses of parenteral penicillin.....	14

2. The results in those patients receiving some form of chemotherapy were better than in those receiving none.

3. The best results in this series were obtained with a combination of local penicillin and oral sulfadiazine.

4. Penicillin in medium dosage (20,000 to 25,000 units every three hours) showed no significant superiority over absence of chemotherapy. However, in a few instances of incipient postoperative wound infection, large penicillin injections (60,000 to 80,000 units every three hours) showed remarkable effectiveness in aborting infection when average doses had failed.

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A PILONIDAL sinus is a developmental defect, usually in the midline over the sacrococcygeal region. A pilonidal cyst is a more extensive congenital defect in the same region, resulting in the formation of an ectodermal cyst.

From "Ambulatory Proctology" by Alfred J. Cantor (Paul B. Hoeber, Inc.).

# HEMORRHOIDECTOMY

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THE relative scarcity of articles in the literature on methods of hemorrhoidectomy would lead one to believe the operation is either of no significance or that the technic had become so well perfected and generally known that nothing further remained to be said. However, one associated with the proctological clinic is constantly presented with evidence that neither is true. The purpose of this article is to present a method of hemorrhoidectomy which has apparently been successful at this hospital for the past two years, in spite of a rather radical departure from the standard pre- and postoperative care. No originality of operative procedure is claimed.

A total of 382 hemorrhoidectomies were performed between November 1, 1943, and October 31, 1945. Follow-ups of four postoperative weeks were made of all the subjects and approximately 50 per cent of the patients have been seen six months to one year postoperatively. No cases have returned for re-operation and no notice has been received indicating re-operation or complications, such as patients are requested to send on discharge from the hospital if such complications do develop. Complications occurred in only one case and that was a seventh day postoperative hemorrhage which recovered following resuture of the hemorrhoidal base. Not a single stricture, perianal abscess, fistula or incontinence has resulted in the above patients.

No attempt will be made to discuss the etiology, pathology, symptoms or diagnosis in this article. Most patients applying for treatment of hemorrhoids present two chief symptoms—bleeding and/or prolapse. Many of the former would undoubtedly receive temporary relief from an injection but because of their occupation as seamen

and the time ashore surgery is advised in all cases with histories of prolapse; operation is usually preferred. Pruritis in our experience is rarely attributable to hemorrhoids but is usually secondary to a chronic cryptitis. The presence of skin tags or external hemorrhoids is a contraindication to injection therapy as their removal is necessary if the patient is to be satisfactorily relieved of symptoms.

*Preoperative Care.* Patients are admitted to the hospital the day prior to operation to allow time for the usual physical examination and routine laboratory tests. Blood coagulation and bleeding times are not determined routinely. The patient is encouraged to eat a regular diet and in the evening before operation is given a plain water enema but no cathartic. The enema is repeated in the morning at 7 A.M. but breakfast is withheld as spinal anesthesia is used in all cases. When surgery is not to be performed before 10 A.M. a breakfast of coffee and toast is allowed. The perianal area is shaved and cleansed with soap and water and on call to surgery the patient is given morphine gr.  $\frac{1}{4}$  (0.016 Gm.), atropine gr.  $\frac{1}{150}$  (0.0004 Gm.) and the usual dose of a barbiturate, usually seconal gr.  $1\frac{1}{2}$  (0.1 Gm.).

*Operation.* The anesthetic used in all cases is low spinal. A 10 per cent solution of procaine is used and 0.3 to 0.4 cc. (30 to 40 mg.) is administered in the fourth lumbar interspace without dilution or barbotage. A saddle type anesthesia results, the legs are rarely paralyzed, reactions are practically unknown and no changes in blood pressure have been noted. The anesthesia in the anal area, with relaxation of the sphincter, persists for a minimum of one hour which provides ample time to deal with any complications that may delay the operation.



The patient is placed in the lithotomy position with the head of the table somewhat low and the buttocks pulled well up between the stirrups, the foot of the table having been dropped. The perianal area is prepared with skin antiseptic (hospital preparation) and the patient draped with leg drapes and hemorrhoidal sheet, the latter being held in place with towel clips. The surgeon sits opposite the anus with an assistant on his left and an instrument table on the right.

The instruments used include two Pennington clamps, a Buie hemorrhoidal clamp, Dudley-Smith operating anoscope, hemostats, suture and tissue scissors and medium No. 0 chronic suture cut in thirds with medium Mayo needles used throughout.

The anal sphincter is gently dilated to encourage its relaxation in order to facilitate operation and for no other reason. No enema or irrigation is administered at operation. If fecal material is present in the lower rectum preoperative preparation has been neglected; however, this is no contraindication to surgery. Several sponges soaked in saline and gently placed in the rectum above the internal hemorrhoidal area will keep the area free of material during the operation. In fact, the sponges often stimulate a reverse peristalsis and will be high in the rectum out of reach at the conclusion of surgery. If this occurs, they are allowed to remain as they are easily passed with the stool postoperatively; it is well to warn the patient that he will pass these sponges in his first bowel movement.

With relaxation of the sphincter the internal hemorrhoids usually present themselves as three main groups—one on the left laterally and two on the right anteriorly and posteriorly. Occasionally smaller internal hemorrhoids will be present anteriorly and posteriorly on each side of the main group on the left side. External hemorrhoidal groups usually correspond to the internal hemorrhoids. Operative technique is essentially dissecting the external hemorrhoidal group free of the sphincter

and up to the internal hemorrhoidal group which is clamped, excised and its base sutured. The external and internal hemorrhoids are grasped by Pennington clamps. Excision of the external hemorrhoid is started well out on the perianal skin and carried up to the line of crypts. It is completely separated from the external sphincter without disturbing the sheath of this muscle. The Buie clamp is placed on the internal hemorrhoid, curved toward the mucosa, taking care to keep it longitudinal to the rectum. Suture is started internally, making the first tie before cutting the hemorrhoid free as occasionally the base of the hemorrhoid will slip through the clamp; if this occurs the tie acts as a guide to complete the suture of the base. After removal of the hemorrhoid flush with the clamp, the suture is carried through the base and over the clamp after the method of Mayo until the line of crypts is reached. Care is taken not to invert or imprison a crypt, as it is believed that this is a common cause of subsequent abscess and fistula formation. The clamp is removed, loops pulled tight and suture tied. Before cutting the suture, the internal hemorrhoidal base is carefully inspected for bleeding between loops. (If this occurs it may be controlled by interrupted sutures.) All veins are then removed from the exposed sphincter and the skin edges of the cut external hemorrhoidal area are lifted, under cut, and as many external veins as possible excised. Care is taken to handle the skin carefully and avoid "buttonholes." Any external arterial bleeding is controlled by clamp and ligation. Arterial bleeding will seldom occur in the external hemorrhoidal area if the sheath of the sphincter is not disturbed.

The external hemorrhoidal base is then closed by interrupted subcuticular sutures; under no circumstances are sutures placed into the sphincter. Each main hemorrhoidal group is treated in a similar manner and the result is longitudinal suture lines with normal bands of skin and mucosa between each. Where small internal hemorrhoids are present anteriorly and posteriorly on



the left side, they are ligated and excised, taking pains to preserve normal tissue between suture lines. In the case of bifid internal hemorrhoids, removal *en masse* as in the usual case is contraindicated, as a segmental mucosal stricture will often result and because the intervening crypt is likely to be imprisoned. In such cases, the bifid internal hemorrhoid is treated by separate ligation of each half, thereby preserving a band of mucosa intact between ligatures in line with the crypt.

A small 6 inch piece of 2 inch gauze impregnated with nupercaine ointment is inserted into the anal canal and a pressure dressing of fluffed gauze and a pad are held in place with tape; the patient is returned to the ward.

*Postoperative Care.* Following operation the patient is encouraged to drink water freely and partake of a regular diet; mineral oil is administered in 1 ounce doses morning and evening for seven days and then a tablespoonful each night for two weeks. The dressing is allowed to remain until the first postoperative morning when it is removed and the patient placed in sitz baths three times a day. Cod liver oil ointment applied externally prevents itching and discomfort in walking. When itching is severe we have found that Calmitol ointment\* is an ideal antipruritic in that it promptly produces symptomatic relief and does not produce a dermatitis venenata as is commonly seen with the use of nupercaine ointment. The patient often has difficulty urinating until the dressing is removed the next morning; prostigmine in 1 cc. doses of 1 to 2,000 administered every one-half hour and an upright position has given relief in all but two patients. These were the only catheterizations performed postoperatively and it is doubtful if they were necessary. In the majority of patients a normal bowel movement occurs on the day following surgery without undue discomfort. On the third postoperative day the patient is placed on a Buie table and the anus gently dilated with the finger; this is done without anesthesia.

\* Thomas Leeming & Co.

Dilatation is performed on the fifth postoperative day and the patient is discharged to outpatient care where dilatations are continued bi-weekly for three weeks. Any skin tags that may have formed are excised under local anesthesia at this time. Mineral oil is stopped after the second week. During outpatient treatment the patient is allowed to work ashore and returns to sea after three weeks.

#### COMMENTS

The almost universal use of agents to inhibit bowel movements appears to accomplish little more than making the patient miserable. In our opinion, the only possible excuse for their use is when the clamp and cautery method is used, as here, and an early bowel movement might result in hemorrhage. That constipating a patient prevents contamination and is in keeping with aseptic technic seems fallacious; great care is taken to constipate the patient in order to prevent contamination but the patient is encouraged to pass flatus. The rectum is allowed to fill up with fecal material but passage through the anus must be prevented at all cost. Mineral oil, on the other hand, is administered in all cases and it is well known how easily this substance slips past the snug sphincter. In short, it seems impossible to apply aseptic principles as such to the anal region and further, it is questionable whether it is necessary or even desirable. Certainly the satisfaction of a good bowel movement is preferable to prolonged constipation. The voluntary relaxation of the sphincter, associated with the dilatation that occurs with the passage, prevents much of the postoperative pain usually associated with hemorrhoidectomy. Lastly, for all intents and purposes the wound is sealed after ten to twelve hours and external contamination will not occur in any event. In spite of Lockhart-Mummery's experience we have not been confronted with any postoperative infections.

Postoperative dilatations are desirable because they not only encourage relaxation of the sphincter but prevent adhesion of

raw surfaces. Strictures are of two types, mucosal and of the skin; mucosal strictures may be complete but are usually segmental and are due to running suture lines into each other—that is, varying from the longitudinal and disturbing the normal intervening bands of mucosa. They are apparently quite common as many cases have been observed in patients operated upon in other hospitals. The operating surgeon, in most cases, remains ignorant of this complication as patients give a history of having no digital or anoscopic examination postoperatively. Fortunately, the complication responds well to a longitudinal incision through the mucosa with the cautery and subsequent dilatation. Strictures of perianal skin occur when too much is excised or when the base of an external hemorrhoid is closed with deep sutures which diminish the circumference of the anal sphincter at relaxation. Sutures externally should be placed only in subcuticular tissue. If the sphincter is included in any suture, its expansion is not only limited but painful postoperative spasms will persist until the suture is absorbed. When a stricture of the perianal skin results, good results can be obtained by partially cutting the sphincter posteriorly and dilatating the anus at regular intervals postoperatively until the wound has epithelialized. Tunnel grafts have not been necessary in the several patients seen here, one of which would not admit a No. 8 uterine sound.

Excision of external hemorrhoids in the manner described, with undercutting of intervening skin and removal of as much of the venous plexus as possible, is necessary to prevent the development of postoperative skin tags and postoperative edema of the perianal tissue. It is impossible to completely control the venous oozing from this region, and closing the excised external hemorrhoidal base prevents free drainage which may result in some hematoma formation in the under cut intervening area. When this occurs, longitudinal slits made through the skin between the excised external hemorrhoids at the end of the

operation will allow drainage and as soon as the pressure pad is applied all oozing will cease. Care should be taken to obtain complete hemostasis at the base of the excised internal hemorrhoids as here the pressure is not effective and bleeding will occur into the rectum and colon.

The incidence of skin tags with this method of surgery is very low and decreases with experience. Tags should be avoided as delayed removal of this excess skin never yields as good results as when they are avoided. This is emphasized because of the popular tendency to leave excess perianal skin in order to avoid a stricture.

Our preference for suture over the ligation method is based on two findings. Ligation results in rather large masses of scar tissue above the sphincter which persist for some time and often become irritated with subsequent bowel movements; furthermore, complete hemostasis is very difficult to obtain. If correctly performed the branch, or branches, of the superior hemorrhoidal artery leading to the internal hemorrhoid will be securely tied by the ligation method. However, venous oozing continues from the exposed area and since it is above the sphincter and no intra-anal pack is inserted significant blood loss may occur. Even when the Lockhart-Mummery method of fixing the ligature to the perianal skin is used bleeding is often significant. Further fixing of the base of the internal hemorrhoid to the perianal skin tends to distort the lower rectum.

The average hospital time of six to eight days, under service conditions, is necessary because patients rarely have a home or family available in the city. In private practice patients would be discharged on the first postoperative day.

#### SUMMARY

A simple method of hemorrhoidectomy has been presented, which if properly performed, will be followed by few complications and should give prolonged relief in the usual case. The pre- and postoperative care has been simplified and less disturbance of the patient's general health results.

# ACUTE GASTRODUODENAL PERFORATIONS

## PLAN FOR POSTOPERATIVE TREATMENT

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IN 1944, at St. Mary of Nazareth Hospital a statistical survey revealed that the morbidity and mortality in perforated peptic ulcer had not decreased appreciably in the last fourteen years regardless of the postoperative treatment used. Therefore, a composite routine method of treatment was instituted which presented morbidity and mortality results forming a more hopeful picture.

### POSTOPERATIVE TREATMENT

After surgery, a Scultetus binder is placed snugly on the patient who is elevated on an upright back rest and encouraged in turning frequently, in deep breathing and in leg movements. During the next forty-eight hours he may occasionally sit on the edge of his bed and may stand for ten minutes in the morning and again in the afternoon. By the end of the fourth day he is completely ambulatory.<sup>1</sup>

A Levine tube, with Wangenstein suction,<sup>2</sup> is placed into the stomach immediately after surgery. For the first three days intravenous feedings are administered consisting of 1,000 cc. of a protein hydrolysate daily<sup>3-5</sup> as well as adequate amounts of 5 per cent glucose in saline or distilled water as determined by fluid intake and output.<sup>6</sup> Vitamin B and C are added to the solutions or are given intramuscularly.<sup>7,8</sup> One ounce of water is given orally at intervals.

On the third day the intravenous feedings are supplemented with an oral protein hydrolysate clamping off the Levine tube for one-half hour. By the fourth day bowel sounds are present, the Levine tube is removed and the routine oral ulcer regimen is started. Penicillin is given in doses depending on the prognostic hours between

perforation and surgery. If these number six or less, the peritoneal cavity is considered sterile<sup>9</sup> and a 60,000 unit initial dose of penicillin followed by 30,000 units every three hours administered intramuscularly is maintained until the patient's temperature is normal (which occurred in all patients by the fourth morning). If seven or more hours elapse, then we are dealing with a *Bacillus coli* or streptococci invasion and massive doses totaling 4,440,000 units of penicillin are given in eight days.<sup>10</sup> The former dosage may be considered prophylactic and the latter active treatment.

The penicillin may be augmented with sulfa therapy.

All patients receive morphine sulphate the first twenty-four hours; a few may require additional doses afterwards. If necessary the barbiturates are administered at night for sedation. The patient is catheterized after twelve hours only if the upright position and psychotherapy fails. On the third day the subject is given 2 ampules of 1:2,000 prostigmine followed in one-half hour by a soapsuds enema.

### STATISTICAL STUDY

Between 1930 and 1944, there were seventy-three patients with perforated peptic ulcer, while between 1944 and 1946, there were twenty-six patients, seventeen of whom received the described treatment. The other nine cases, seven of which occurred in 1944 and one each in 1945 and 1946, were not so treated because of the difficulties found in private hospital practice and not because the cases were selected. During the entire sixteen years there were one hundred patients with perforated peptic ulcer comprising one admission for every 640 surgical cases admitted per year.

Out of seventy-three patients three or 4.7 per cent were females; out of the seventeen patients one or 5.9 per cent was female.

The highest incidence of perforation occurred in the fourth decade. The average age for the first seventy-three patients was

TABLE I

Hours Between Perforation and Surgery	1930-1944			1944-1946		
	No. Liv- ing	No. Dead	Per Cent Dead	No. Liv- ing	No. Dead	Per Cent Dead
4 or under	28	6	17.6	11	0	0
5-10	14	9	39.1	4	0	0
10-24	5	7	58.3	1	0	0
24 and over	1	4	80	1	0	0

forty-two years; the average for the seventeen was forty-seven years. The youngest patient was twenty and the oldest was seventy-seven.

Thirty-eight per cent of all patients had no previous history of symptoms, while 62 per cent had histories ranging from one week to twenty years, the average being two years. In the seventy-three patients the average duration was 8.8 hours; that for the seventeen patients was 6.3. This decrease is attributed to early diagnosis and immediate surgery. (Table I.)

Roentgenograms were taken of twenty-three patients and were positive in fourteen (60 per cent). Drop ether was used from 1930 to 1934, and ether and ethylene from 1934 to 1943. Spinal anesthesia was used five times; ether and cyclopropane, ether and novocaine and ether and nitrous oxide once each. In the seventeen cases intravenous pentothal sodium and cyclopropane were used exclusively, supplementing this in the last five cases with curare to further relaxation.

The location of the perforation was gastric in eight patients, 47 per cent, and duodenal in nine, 53 per cent. This is at variance with the seventy-three patients in which 26 per cent were duodenal and 74 per cent gastric. (Table II.)

In all cases simple black silk suturing and reinforcement with omental graft was used to close the perforation. The abdomen was closed with chromocized catgut and dermal; tension button sutures were used in the seventeen patients. The operating

TABLE II

Site of Ulcer	Cases 1930-1944	Deaths 1930-1944
Duodenal region, anterior.....	17	4
Gastric region, anterior.....	12	6
Pyloric region, anterior.....	22	4
Lesser curvature.....	13	6
Near esophagus.....	1	1
Gastric region, posterior.....	1	1
Pyloric region, posterior.....	1	1
Duodenal region, posterior.....	1	0
	1944-1946	
Duodenal region, anterior.....	9	0
Gastric region, anterior.....	8	0

time varied from twenty-seven to ninety-five minutes with the average time being fifty-four minutes. Thirteen of the seventeen patients, 76 per cent, had no drains; two subjects had one drain and two had two drains. In the seventy-three patients seventeen or 23.3 per cent, had no drains and fifty-six had from one to eight drains. Temperature, pulse and leukocyte counts were tabulated but no clinical or statistical correlation was seen.

In the seventy-three patients the post-operative treatment varied according to the teaching of the times. In the seventeen patients the treatment was standardized as outlined in Table III.

In the seventy-three patients wound abscesses occurred in four and evisceration in twelve, in all, 52 per cent had complications. In the seventeen cases only two patients, 11.6 per cent, had complications consisting of wound infection and evisceration. In terms of the amount of days at the hospital the treatment was justified. Most patients are walking around the ward, feeling and looking well enough to go home by the fifth day. Eleven patients went home in eight to ten days; five patients in ten to fifteen days and one patient in

twenty days. The average hospital stay was 10.8 days, while the average stay for the seventy-three preceding patients was 19.5 days. This is a decrease of 8.7 days.

Out of the seventy-three subjects there were twenty-four deaths 32.9 per cent. These correlated with hours' duration

routine postoperative treatment which was presented.

3. The hospital stay was reduced from 19.5 days to 10.8 days and no mortality was noted in the seventeen patients as against a 32.9 per cent mortality in the seventy-three.

TABLE III

## POSTOPERATIVE TREATMENT

## First Twenty-four Hours

1. M.S. gr.  $\frac{1}{6}$  q6h
2. Elevate the head of the bed
3. Insert Levine tube with Wangenstein suction
4. 1,000 cc. of a protein hydrolysate given intravenously
5. 1,000 cc. of 5 per cent glucose given in saline  
1,000 cc. of 5 per cent glucose in distilled water  
(Repeated according to the fluid intake and output)
6. Vitamin B and C given either intravenously or intramuscularly
7. Administration of penicillin

## Second Twenty-four Hours

1. Repeat as above
2. Let the patient stand ten minutes in the morning and ten minutes in the afternoon

## Third Twenty-four Hours

1. Repeat as above
2. Oral protein hydrolysate ounces  $\frac{1}{2}$ , given four times a day, shutting of the Levine tube for one-half hour
3. Administration of 2 ampules of prostigmine in the afternoon followed by a soapsuds enema in one-half hour

## Fourth Twenty-four Hours

1. Remove Wangenstein and Levine tubes
2. The patient is now completely ambulatory
3. The regular ulcer diet management is followed.

(Table 1) but not with the ages. There were no deaths among the seventeen patients which is attributed to the small series and the majority of cases having a duration of less than ten hours.

Follow up studies of the seventeen patients reveal that all are back at their original jobs and have no symptoms referable to the ulcer. Contrary to their physician's advice thirteen patients are not on a strict diet and fourteen are not taking medication.

## SUMMARY

1. Ninety cases of gastroduodenal perforations were reviewed with a comparative study of the first seventy-three patients as against the last seventeen.

2. Seventeen patients between 1944 and 1946, were treated with a composite

TABLE IV

Complications	1930-1944	
	No. of Cases	No. of Deaths
Evisceration.....	12	0
Peritonitis.....	11	11
Pneumonia.....	6	6
Wound infection.....	4	0
Shock.....	3	3
Diabetes.....	2	2
Parotitis.....	1	1
Fecal fistula.....	1	0
Blood transfusion reaction.....	1	1
1944-1946		
Evisceration.....	1	0
Wound infection.....	2	0

4. A follow-up study of the seventeen cases was presented.

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# DIVERTICULA AND OTHER MUCOSAL-LINED AND PATHOLOGIC OUT-POUCHINGS OF THE GASTROINTESTINAL TRACT\*

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THE purpose of this paper is to discuss briefly the more common types of gastrointestinal sacculations, and with the aid of photographs, to describe several illustrative cases that have been observed by the author. The anatomical sites of occurrence of these lesions will serve as an outline for discussion. Lesions of the esophagus, stomach, duodenum, jejunum, ileum, appendix and colon will be considered in sequence.

## ESOPHAGUS

In the esophagus, two varieties of out-pouchings are encountered; they are known as the traction and the pulsion types of diverticula. Traction diverticula are usually situated at the level of the bifurcation of the trachea. They are thought to be caused by the pull of adhesions which have resulted from infection in the adjacent lymph nodes. They are usually small, have no dependent sacs and rarely give rise to symptoms. They are a common occurrence and are frequently discovered by accident. These lesions have little clinical significance and usually require no surgical treatment. Pulsion diverticula are found at one of two locations and form two distinct problems.

In the lower third of the esophagus, one occasionally finds an enlargement that may progress to the degree of sacculation. Such a dilatation is considered to result from cardiospasm. Relief and regression usually follow instrumental dilation of the cardiac orifice of the stomach.

The site of the most important variety of esophageal diverticula is at the pharyngo-

esophageal junction. Almost invariably the lesion will be found posteriorly. The repeated impact of bolted food upon the comparatively weak part of the pharyngeal wall above the cricopharyngeus muscle, upon which the neck of this type of diverticulum rests, is believed to be of great importance in the etiology. Symptoms, which are proportional in severity to the size of the sac, usually develop over a long period of time and become progressively more severe. The patient may complain of a feeling of fullness in the neck, which is more marked after eating, and some difficulty in swallowing or breathing may be present. He may regurgitate undigested food long after eating, especially if pressure is exerted upon the neck from without. Eventually, only liquids may be tolerated with the resultant development of general symptoms of mild starvation such as weight loss, anemia, hypoproteinemia and alteration of acid-base balance and fluid equilibrium. The diagnosis in such cases is confirmed by x-ray studies made while the patient swallows a radio-opaque liquid. Figures 1 and 2 illustrate a collection of barium mixtures outlining a diverticulum.

CASE 1. This lesion was discovered in a fifty-three year old white male, who was admitted to the hospital for the repair of a recurrent inguinal hernia. In giving his history the patient related that for the past fifteen years he had had a "nervous condition of the throat." Careful investigation revealed a lesion as shown in the illustrations.

A two-stage operation was performed on this patient with excellent results. At the first stage,

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FIG. 1. Postero-anterior roentgenogram of the chest showing a collection of barium in the midline at the root of the neck.

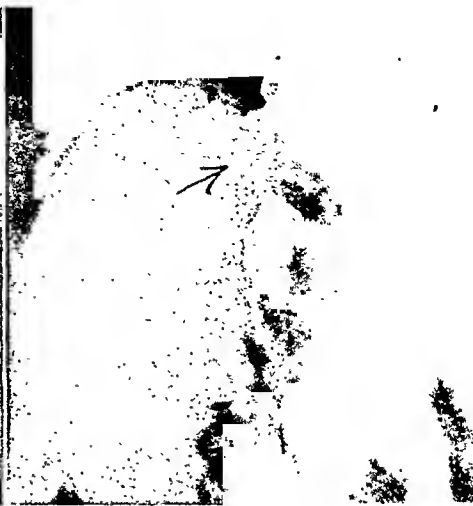


FIG. 2. Lateral x-ray film of the same chest shown in Figure 1. The collection of barium is seen posterior to and communicating with the esophagus. Diagnosis: esophageal diverticulum.

the sac was mobilized, suspended and the fundus exteriorized. A drain was inserted deep into the neck beside the sac for the purpose of stimulating the sealing off of a tract. The operation was done under intratracheal, general anesthesia without the aid of an inlying esophagoscope.

Eight days later, the wound was re-opened and a ligature of silk was placed around the neck of the sac near the esophagus. The fundus was then incised and a large cone of mucosa dissected free and removed. The redundant portions of the wall were excised; the remaining wall, devoid of mucosa, then collapsed and was compressed by the musculature of the neck. The wound was closed. The patient made an uneventful recovery.

At operation, the introduction of a lighted esophagoscope may greatly aid in finding the diverticulum. Also, with the use of paravertebral and local injections of novacaine for anesthesia, the patient is able to swallow during the operation and the location of the sac is accordingly somewhat easier.

A dreaded complication of this operation is mediastinitis. The esophagus is notoriously slow in healing, and such a complication is not uncommon following injuries or operations. Some men advocate complete extirpation of the sac at one operation; however, the author believes that the procedure of mobilizing the diverticulum

and providing for the establishment of a protective wall at one sitting and re-operating at a later date for removal of the lesion affords a greater degree of safety.

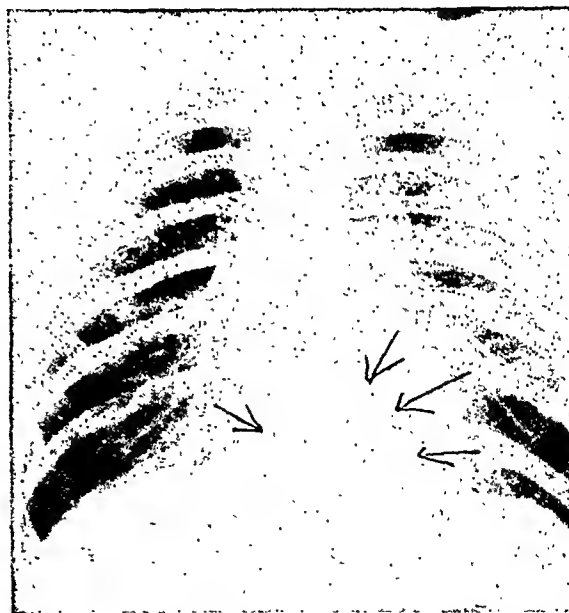


FIG. 3. Postero-anterior film of chest. The arrows outline an ill-defined, indefinite mass.

#### STOMACH

Diverticula of the stomach are relatively uncommon. They are usually found in the region of the fundus. When discovered, they are frequently associated with another lesion that has given rise to the symptoms. In a recent review of the literature, Moses found that only 150 cases had been re-





FIG. 4. The mass mentioned under Figure 3 is more clearly visualized as a result of alteration of technic.



FIG. 5. Following ingestion of barium, the mass referred to in Figures 3 and 4 is seen to fill with the opaque medium and is located above the diaphragm. Diagnosis: diaphragmatic hernia (para-esophageal).

ported and that approximately one-third only of these gave rise to any symptoms. The sole use of the term "diverticula" would preclude the discussion of trans-

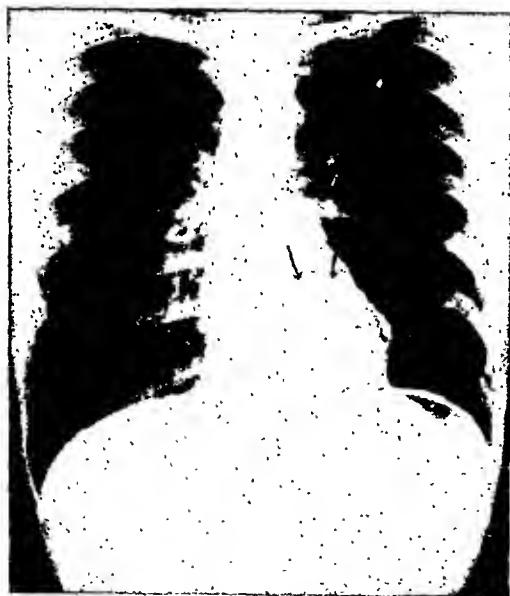


FIG. 6. Postero-anterior roentgenogram showing a circumscribed mass in the mediastinal region. A fluid level is present.

diaphragmatic herniations of the stomach into the thorax which are rather important out-pouchings that cannot be described as diverticula.

For simplicity, lesions of this type will be called congenital or acquired. These terms are self-explanatory. Trauma of some type is, for all practical purposes, the greatest causative factor of the acquired type. One must realize that the term, "diaphragmatic hernia," does not exclude those conditions in which organs other than the stomach herniate into the thorax. Articles have been written describing almost every abdominal organ as having been found in the chest.

In this paper, two cases will be described in which the stomach was the only organ to enter the chest cavity through the diaphragm. One lesion was probably congenital in origin and the other traumatic. The symptomatology of both of these cases was very vague and led one to suspect indefinite, functional disorders. It was only by x-ray studies that the actual diagnoses were made and only at operation could the true causative factors be determined.

CASE II. A twenty-eight year old white male gave a history of indigestion, nausea, epigastric discomfort and occasional severe





FIG. 7. The mass seen in Figure 6 is now filled with barium.

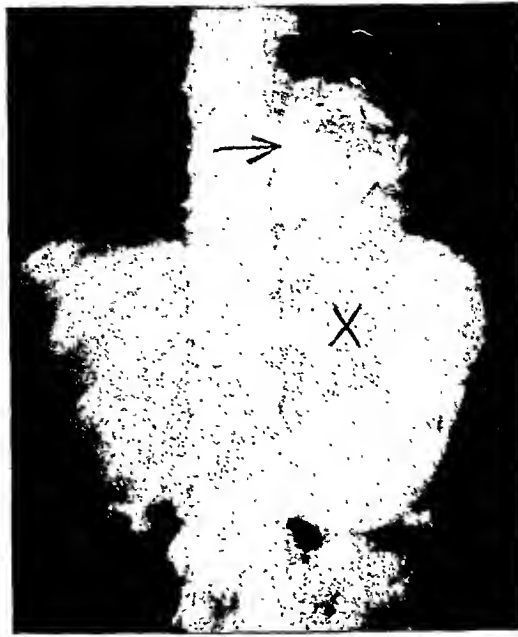


FIG. 8. The purpose of this film is to show that the mass referred to in Figures 6 and 7 is lined with gastric mucosa. Diagnosis: diaphragmatic hernia.

pain. These symptoms had been present for as long as he could remember and at times had been very severe, sometimes lasting for several days. No history of trauma could be obtained. X-ray studies were made. Films (Fig. 3) revealed an indefinite density as marked by the four arrows. With a change in technic and repetition of the chest plate, the aforementioned dense area was more clearly outlined as shown in Figure 4. It was only when the patient was given barium to swallow and an x-ray film was taken that the true significance of the mass was ascertained. Figure 5 shows an isolated out-pouching of the stomach located within the thoracic cage.

The patient was prepared for operation. Intratracheal, general anesthesia was used and a high abdominal approach was made through the left rectus muscle. Additional exposure was obtained by cutting the left coronary ligament of the liver. Only then could a herniation be demonstrated. Because the out-pouching was covered by a sac of parietal peritoneum, it was concluded that the lesion was a congenital, para-esophageal herniation of the stomach through the esophageal hiatus of the diaphragm. The affected portion of the stomach was removed from its peritoneal sac by sharp dissection. The greatly enlarged hiatus was reduced in size by denuding the edges and approximating part of the circumference with fascia lata. The abdomen was closed in layers.

Immediate postoperative therapy consisted

of continuous gastric siphonage, oxygen inhalation and control of pain by the use of morphine. The patient did well for eleven days and the wound healed normally. On the twelfth day, he experienced severe chest pain, became dyspneic and cyanotic, spat up quantities of frothy blood and died within fifteen minutes following the onset of his symptoms. At autopsy, the repair in the diaphragm was found to be healing properly. The cause of death was a large pulmonary embolus in the right lung. It was interesting to note that the left lung was satisfactory. The patient had given no antemortem signs or symptoms of a phlebothrombosis.

**CASE III.** A thirty-five year old white male complained of indigestion and other vague gastric symptoms. He dated the onset of these symptoms to a year previous when he was squeezed and rolled between a truck and a box car. At that time, he was in a hospital for three weeks and seemed to improve satisfactorily. As part of the investigation of his symptoms, a flat plate of the upper abdomen and chest was taken. As can be seen in Figure 6, a mass and fluid level were discovered in the thorax. Following ingestion of barium, this mass (Fig. 7) was found to be an out-pouching of the gastrointestinal tract. A film was taken later (Fig. 8) after sufficient time had elapsed for some of the barium to pass through. In this



FIG. 9. X-ray film of abdomen, taken following ingestion of an opaque meal, revealing a large collection of barium. By subsequent studies this collection was found to empty very slowly.



FIG. 10. Same case as shown in Figure 9. The duodenum is well outlined. The small circle indicates the site of the communication, as later determined by operation, between the third part of the duodenum and the diverticulum. Diagnosis: duodenal diverticulum.

plate, gastric rugae could be demonstrated to prove that the out-pouching was the stomach.

Under intratracheal, cyclopropane anesthesia, an incision was made over the left

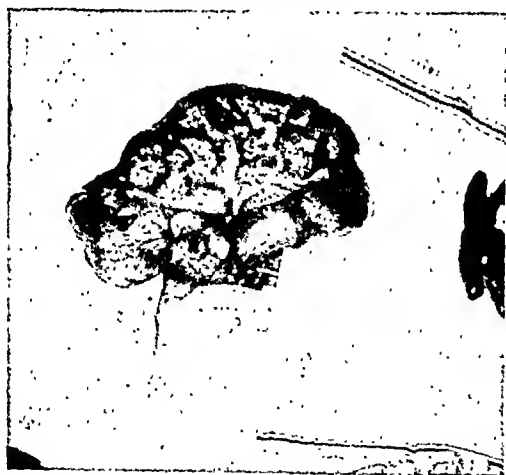


Fig. 11. Photograph taken at the time of operation. Many sacculations of various sizes can be seen communicating with the small intestines. Diagnosis: multiple diverticulosis of the small intestines.

found to communicate with the remainder of the stomach by a very small tube. Payr clamps were applied to this tube very near the stomach proper. The tube was divided between the clamps with a cautery and the remaining small stump inverted. The intrathoracic mass was then removed. The rent in the diaphragm was sutured with heavy chromic catgut and fresh strips of fascia lata. All bleeding was controlled, the left lung re-expanded and the incision in the chest wall closed in layers. This patient made an excellent recovery. The operation disclosed that the extruded portion of the stomach had not carried before it a sac of parietal peritoneum. Therefore, the lesion was, in all probability, an acquired, traumatic type of diaphragmatic hernia. This conclusion was substantiated, of course, by the history of trauma.

Because of the multiplicity of locations and varieties, there can be no one type of treatment suitable for all diaphragmatic hernias. Opinion is rather divided among present day surgeons as to whether the approach should be by the abdominal or the thoracic route. Each approach has certain advantages; therefore, personal judgment in individual cases should govern the management.

cighth rib. Subperiosteal resection of this rib was performed and the left pleural cavity opened. Reduction of intrapulmonary pressure permitted the left lung to collapse and a large mass was found extending through the diaphragm; many adhesions were encountered. The left phrenic nerve was crushed and the mass freed. The existing opening in the diaphragm was enlarged. The portion of the stomach located within the thoracic cage was



FIG. 12. Roentgenogram of abdomen taken following ingestion of barium. In the pelvic region, a barium filled sac is clearly outlined. Diagnosis: Meckel's diverticulum.

#### DUODENUM

Diverticula of the duodenum are not rare. Here again, however, the lesion gives rise to no symptoms in the great majority of instances and discovery is frequently coincidental with x-ray studies, operations or autopsies. In the usual case, the sac is small, its neck large and its emptying time rapid. Few pathological changes occur under these conditions. On the other hand, if the pouch has a small outlet and retention occurs, inflammation is likely to result, giving rise to pain, bleeding and various other disturbances, and progressing possibly to perforation. Many of the cases presenting symptoms do so to such a mild degree that surgical intervention is unnecessary; but at times operative correction is the only method by which permanent relief may be obtained.

As regards etiology, it is generally believed that there is a congenital defect in the circular and longitudinal muscle coats and that the remaining wall, consisting of mucosa and muscularis mucosae, gradually becomes weaker and extrudes. Both congenital and acquired factors are, therefore, active in the etiology.



FIG. 13. Photograph taken at operation showing an out-pouching of the ileum as described first by Meckel. The patient was operated upon because of a pathological condition of the diverticulum itself.

The case to be described was rather typical of the occasional type requiring surgical treatment, and is similar to one reviewed by Lahey and Marshall.

CASE IV. The patient was a forty-three year old white male admitted to the hospital because of upper abdominal discomfort and indigestion. These symptoms were of several years' duration and were becoming progressively more severe. Symptoms, such as delayed character of pain after eating, intolerance to certain foods, midline epigastric tenderness, nausea and vomiting were also present. Barium meal x-ray studies revealed a large diverticulum of the duodenum as shown in Figures 9 and 10. There was marked delay in emptying time of the diverticulum. For eight months, this patient was treated with diet, alkalies and antispasmodics. There was no improvement and operative interference was advised.

Under general anesthesia the abdomen was opened by means of an epigastric, transverse incision. Exploration of first and second portions of the duodenum was carried out, but the neck of the sac could not be found here. The transverse colon was reflected superiorly, and, just to the right of the superior mesenteric vessels, the neck was discovered. The body of the diverticulum rested anterior to the head of the pancreas. It was thought remarkable that the sac in this position had not at some time given rise to symptoms of acute gastro-



FIG. 14. X-ray film of abdomen showing the colon filled with an opaque medium. The arrows point out a defect in the lower left colon.



FIG. 15. X-ray film of same case as shown in Figure 13. The colon has been emptied and then inflated with air. A small out-pouching is seen at the site of the defect mentioned in Figure 13. The arrows indicate the sites of other small sacculations. Diagnosis: Multiple diverticulosis of the colon.

mesenteric ileus. The diverticulum was mobilized and its neck severed between clamps with a cautery. Careful closure of the stump was performed and the abdomen closed. A Levin tube had been previously inserted. The tip was allowed to remain in the duodenum for three days. The patient had an uncomplicated recovery and became symptom-free.

#### JEJUNUM AND ILEUM

Diverticulosis of the small intestines is so rare that it is almost unique. Figure 11, however, shows just such a case. This picture, taken at operation, shows multiple out-pouchings, all with a sessile type of base. The patient was a fifty-five year old white female. She had had two previous laporatomies in her second decade. The operation disclosing the diverticula was performed, not because of the diverticulosis but to relieve an acute intestinal obstruction caused by old adhesions. This case is presented to show, by means of the photograph, that multiple diverticulosis of the small intestines may and does occur.

#### MECKEL'S DIVERTICULUM OF THE ILEUM

During fetal life, there is a duct-like communication between the mid-gut and the yolk sac. It has been estimated that in 2 to 4 per cent of births, this vitello-intes-

tinal duct fails to disappear completely. A variety of types of omphalomesenteric pathology may result.

Since this paper is dealing with out-pouchings of the intestinal tract, only that type will be discussed in which the incompletely obliterated omphalomesenteric duct may be found with the proximal or intestinal end attached to some portion of the antimesenteric side of the ileum (usually 20 to 100 cm. proximal to the ileocecal valve) and with its distal end free. This condition was originally described by Meckel in 1815 and has since become popularly known as Meckel's diverticulum. Many such diverticula cause no symptoms throughout life and may be discovered at autopsy. However, when pathological changes do take place, they usually fall into one or more of the following categories: First, there may be partial or complete intestinal obstruction resulting from pressure or traction on the gut from without or from intussusception due to invagination of the sac. Gerwig and Stone in 1943 discussed acute enteric intussusception and mentioned Meckel's diverticulum as one of the etiological factors. Second, there may be

inflammatory changes not unlike those of appendicitis with possible resultant perforation and peritonitis or abscess formation. Third, there may be evidence of hemorrhage into the bowel in some of those occasional cases in which aberrant gastric mucosa is present in the sac.

In those cases in which symptoms arise from pathological changes in a Meckel's diverticulum, the treatment is surgical intervention. The x-ray reproduced in Figure 12 shows a non-symptomatic Meckel's diverticulum filled with barium. Another Meckel's diverticulum as seen at operation is pictured in Figure 13.

#### APPENDIX

The appendix is undoubtedly the most common mucosal-lined out-pouching of the gastrointestinal tract to undergo pathological changes. No effort will be made to review this large subject in this paper; however, reference is made to a recent article by the author in which the subject of appendicitis is more completely considered.

#### COLON

Out-pouchings of the large intestine, known as "multiple diverticulosis of the colon," are extremely common. It has been estimated that 3 to 5 per cent of all persons over forty years of age have diverticulosis of the colon, but that only 10 per cent of all cases of diverticulosis of the colon undergo inflammatory changes and develop diverticulitis. Diverticulitis of the colon is not in itself an indication for surgery, but rather, in the majority of cases, best managed by conservative means. The subject of acute diverticulitis of the colon was reviewed in a paper by Shipley and Gerwig in 1939. Some of the more pertinent findings will be repeated in this paper.

Diverticula of the colon are divided into two classes, the congenital or true type and the acquired or false type. In the former, the wall of the diverticulum consists of all coats of the intestine, while in the latter, there is a thinning out or absence of the circular muscle with herniation of the

mucosa and submucosa. It is the acquired type that most frequently gives rise to symptoms.

Even though diverticula may be found distributed through the entire colon, the descending and sigmoid colon are the sites of 60 to 75 per cent of the diverticula that undergo inflammatory changes. This fact is thought to be due to the more firm consistency of the stool and to the greater effects of constipation and gaseous distention in that region.

The history may reveal that the diverticulitis is acute, chronic or recurrent. Chronic diverticulitis of the sigmoid must be differentiated from carcinoma. Figure 14 reveals a defect in the sigmoid region. From this one film, carcinoma cannot be ruled out. However, in Figure 15, which represents a view taken after the barium had been evacuated and the colon inflated with air, numerous diverticula are seen.

It must be emphasized that only a small per cent of diverticula of the colon undergo pathological changes with resultant diverticulitis, and that only a small per cent of the cases of diverticulitis require surgical intervention.

Surgical intervention is not indicated for simple diverticulitis *per se*, but rather should be undertaken for the complications, which are abscess formation, peritonitis, obstruction and fistula. Operation may sometimes be justifiable because of uncertainty as to the diagnosis in the acute condition of the abdomen, this being particularly true when the site of the lesion is the cecum.

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# A NEW TENSION SUTURE TECHNIC\*

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IT has been shown by a number of investigators<sup>1-3</sup> that the purposes of a suture are (1) coaptation of tissues and (2) holding of tissue in a certain position for a short time until fibrin is formed and the actual healing process sets in. In the

Therefore, in the following a method of suturing is described which will reinforce the tissue under tension, no matter which suture material is used: silk, cotton, wire, chronic catgut or others.

A continuous suture line ("gimp") is

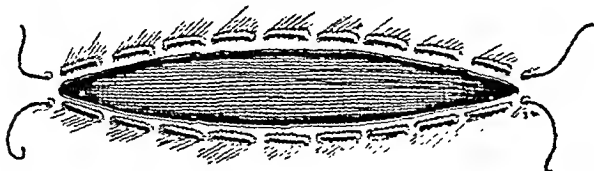


FIG. 1. Continuous sutures placed.



FIG. 2. Sutures placed and ends tied.

presence of tension or weakness of tissues, suture material of a tensile strength surpassing that of the tissues is of no avail. In such a case, under a strain the suture will cut through the tissue instead of tearing, and the result will again be wound separation.

placed parallel on either side of the incision or intended coaptation line (Fig. 1); the corresponding ends of the sutures are then tied to each other under slight tension (Fig. 2), and a closing interrupted or continuous stitch is then placed in such a manner that the new suture would rest on the previous

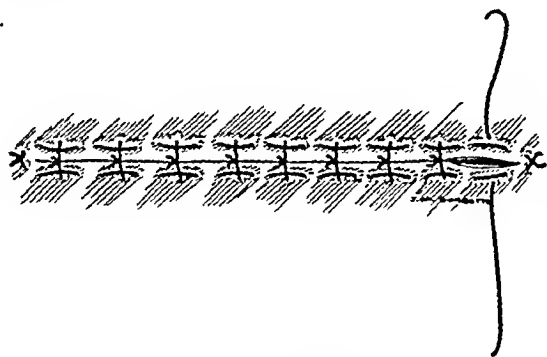


FIG. 3A, interrupted closing sutures placed.

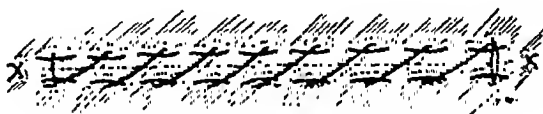


FIG. 3B, continuous closing suture placed.

Open reinforcing suture lines have been recommended for soft parenchymatous tissues, such as liver<sup>4</sup> and kidney. These reinforcing sutures were not tied to each other and can therefore not be used for tissues under tension. This latter procedure anchors the supporting parallel sutures, which are tied under slight tension to facilitate coaptation and decrease traction on the main closing suture line.

parallel suture lines. (Fig. 3.) The closing stitch may be of any desired type,<sup>4,5</sup> such as interrupted, continuous, mattress, Connell,<sup>6</sup> Halsted,<sup>7</sup> etc.

In experiments it could be shown that such a procedure increases many times the resistance to sudden or gradual traction. Also in end-to-end or lateral anastomosis of the bowel in postmortem experiments a single line anastomosis proved perfectly air

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and water-tight without formation of a diaphragm effect due to too much inversion.

This type of stitch should also be especially helpful for suturing of weak tissues under tension, such as esophagus, muscles, peritoneum, thin layers of fascia and tendons.

#### CONCLUSION

A tension suture is described utilizing two parallel suture lines ("gimps") for reinforcement of the tissues and support of the main closing stitch.

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SUTURES, combined with an anterior wire loop by the method of Martin, recommended by Campbell, make a very satisfactory reduction and fixation of a fractured patella. . . . Total excision of the patella as practiced by Brooke is not recommended as routine practice, but undoubtedly will give good results and may be used in extensive compound comminuted fractures.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# EARLY POSTOPERATIVE AMBULATION\*

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THE purpose of this paper is to describe the method used in early postoperative ambulation in 144 cases of varied abdominal operations performed by the author since July 1944.

Historically, early surgical ambulation dates back to 1899 when Ries in a written report advocated this practice. Since then, especially in this country, the idea has been adopted by only a few surgeons. However, within the last few years postoperative rising has gained in popularity. Although early postoperative ambulation can be used practically in all types of surgery, this paper limits itself to abdominal procedures as the greatest degree of skepticism regarding early rising exists in this field of surgery, chiefly because of the erroneous concept of increased wound dehiscence and hernia formation.

The most important advantages are decreased pulmonary and circulatory complications which result mainly from basal atelectasis and peripheral venous stasis. Clinically, this fact is supported by lower postoperative temperatures, an earlier return to normal and a lower pulse rate as compared with the strictly confined bed patients; such observations were made and recently reported by Powers, Shafer and Dragstedt. Physiologically, it has been shown by Leithauser that the vital capacity in early ambulatory patients returns to normal in approximately one-half the time required for bed confined postoperative patients, while McMichael and McGibbon have demonstrated that recumbency decreases the total volume of air in the fully expanded lungs as well

as the functional residual air. The studies of Smith and Allen revealed that exercise decreases the circulation time in the extremities.

Other advantages include reduced frequency of abdominal distention, absence of asthenia, shortened hospital duration and early restoration to normal activity. Having the patient attend to his personal hygiene and lessening his hospital stay are of great importance psychologically and economically, to the patient as well as to the community having limited hospital beds, nursing personnel or in a time of emergency.

If early postsurgical rising is to be practiced, abdominal closures must be considered as one of the most important parts of the operation instead of a necessary finale. Rapid unanatomical closures result in frequent wound dehiscence under any circumstances. Consequently, such closures along with grossly infected wounds are considered a contraindication to early rising.

All abdominal incisions regardless of their location are closed anatomically layer by layer with interrupted No. 24 cotton sutures. In the peritoneum and posterior rectus sheath these sutures are placed no further than 1 cm. apart and only a minimal amount of tissue is included in each suture. All knots are tied squarely with an additional knot added so that the sutures can be cut adjacent to it. In oblique or transverse incisions where the muscle tissue has been severed, the cut muscle is loosely approximated by sutures inserted somewhat further apart. The anterior fascial

\*The surgery and postoperative management referred to was performed at the Bronx Veterans Hospital New York City by Dr. Balcer during his assignment as assistant chief surgeon and is not to be construed as official or reflecting the views of the Veterans Administration or the Army Medical Corps. Presented as a narrated film before the Section of Surgery of the New York Academy of Medicine January 4, 1946.



layer is made secure by interrupted No. 24 cotton sutures also placed about 1 cm. apart. Maximum relaxation is extremely desirable and necessary to prevent the sutures from pulling through the tissue. Needless to mention, but certainly of extreme importance, is perfect hemostasis. For this purpose mosquito forceps are used exclusively so that only small portions of tissue are grasped in each bite. Fine cotton ligatures, usually No. 60 to 100, are used to replace the hemostats but cautery is often used for this purpose. The skin is sutured by whatever method suits the operator's taste.

All patients are allowed out of bed the morning of the first postoperative day except when definite contraindications are present. These, in addition to those already mentioned, are shock, severe abdominal distention, cardiac decompensation and second side thoracolumbar sympathectomies and demonstrable vasomotor instability in the upright position. In the extremely aged and when pulmonary difficulties were suspected as in chronic asthmatics, arising was conducted late in the afternoon of the operative day. Prior to surgery, specific instructions in the manner of getting out and into bed were given to each patient by the nurse in charge of the ward, and if at all possible a rehearsal should be performed.

The method in brief, consists of having the patient turn on his side and winding the bed to a sitting or semisitting position. The feet are then assisted over the edge of the bed by the attendant and with the help of the nurse the patients sits on the side of the bed. The next step consists of standing for a few seconds and taking deep inspirations. This usually results in a productive cough, a very desirable feature, the mechanics being the emptying of the accumulated bronchial secretions often a forerunner to pulmonary atelectasis. The patient then walks to a chair and sits down for a few minutes, or longer if so desired. The return to bed is accomplished in the same manner but in the reverse order. The entire

procedure is again repeated in the afternoon; at this time most patients usually walk for short distances and stay up somewhat longer periods of time. On each successive day the degree of activity is gradually increased so that at the end of the week the preoperative status is reached.

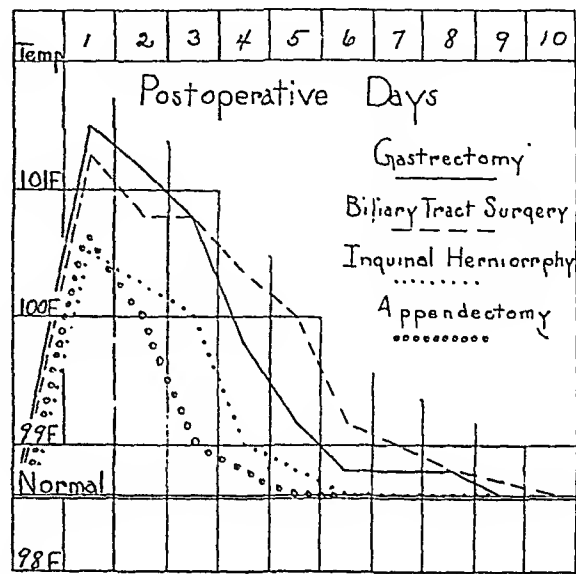


FIG. 1. Postoperative average rectal temperatures. Note sharp fall in temperatures and absence of secondary elevation.

Examination of the operative list in Table I reveals a total of 144 cases with one death and eight complications. The one death resulted from biliary and pancreatic leakage following a partial gastrectomy for

TABLE I  
LIST OF OPERATIVE CASES

Operation	No.	Deaths	Complications
Partial gastrectomy.....	33	1	3
Biliary tract surgery.....	22	..	2
Herniorrhaphy, all types.....	42	..	2
Appendectomy.....	21	..	1
Sympathectomy.....	11		
Closure of duod. ulcer perf....	3		
Gastroenterostomy.....	2		
Drainage of subphrenic abscess	2		
Cecostomy.....	2		
Resection of marginal ulcer...	1		
Resection of sigmoid colon...	1		
Closure of abd. evisceration...	1		
Ileostomy.....	1		
Splenectomy.....	1		
Drainage of app. abscess.....	1		
Total.....	144	1	8

a deep-seated duodenal ulcer. The complications include three cases of pneumonia, two following gastrectomies and one subsequent to a ventral herniorrhaphy. All recovered following treatment. Small hematoma formations resulted in two wounds, one a gastrectomy and the other a ventral herniorrhaphy. A single wound infection appeared after an appendectomy. Penicillin therapy resulted in a spontaneous resolution of a probable subphrenic abscess which developed after a cholecystectomy. The remaining complications, a case of parotitis, appeared after gallbladder surgery but completely subsided under x-ray treatment. It is obvious that none of the complications mentioned can be attributed to the practice of early postoperative rising.

The graph in Figure 1, displaying postoperative temperatures includes four groups of abdominal operations. This was done for the sake of simplicity. The highest rectal temperatures for the respective days were averaged and plotted. It is noted that the highest temperatures occurred on the first postoperative day, followed by a comparatively sharp fall with normal temperatures occurring on the fifth to the tenth day. The sudden, sharp, increased temperatures often seen on the second, third and fourth days, which are indicative usually of pulmonary complications, are noticeably absent in this group.

Although the above figures on the results obtained indicate to some degree the ad-

vantages of early post-operative ambulation, the real benefits can be fully appreciated only by actually watching a group of patients undergo this form of post-operative management. The improved general appearance of the patient, the absence of abdominal distention, the reduced necessity of catheterization and gastric decompression and the very infrequent need for oxygen therapy makes a vivid impression on the surgeon as to the astounding progress postsurgical patients make when conditions are made as physiological as possible.

In conclusion it may be said that early postoperative rising following abdominal surgery minimizes the frequency of post-operative complications, aids in the faster restoration of the normal state physically and mentally and in no apparent way interferes with normal wound healing.

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# Case Reports

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## SUPERIOR MESENTERIC ARTERIAL OCCLUSION

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**E**XTENSIVE resections of the intestine may be necessary in a number of conditions. Haymond, in an analysis of 257 collective cases, gives the following causes as the most frequent: (1) volvulus, (2) strangulated hernia, (3) mesenteric thrombosis, (4) diseases of the pelvic organs with secondary involvement of the intestine, (5) diseases of mesentery, particularly tumors, (6) abdominal injuries, (7) tuberculosis of the small intestine and (8) miscellaneous causes, adhesions, etc.

The case we are reporting was one of mesenteric thrombosis in a man of sixty-four years with extensive peripheral arteriosclerosis. It is our opinion that extensive arteriosclerosis of the superior mesenteric artery was responsible for the mesenteric thrombosis in the case in question, the thrombosis occurring apparently just distal to the origin of the middle colic branch of this artery. No other apparent etiologic factor was present except auricular fibrillation. This was transient and occurred after thrombosis had developed, consequently was not an obvious cause of embolism. "The syndrome which develops with occlusive lesions in the mesenteric arteries resulting in infarction of the bowel, is by far the most definite clinical expression of arteriosclerosis of the abdominal vessels."<sup>6</sup>

### SYMPTOMS AND DIAGNOSIS

The outstanding symptom of mesenteric thrombosis is severe generalized abdominal pain of sudden onset, associated with nausea and vomiting, simulating acute perforating peptic ulcer, acute hemorrhagic pancreatitis or dissecting aneurysm of the aorta. The pain is excruciating and requires

large doses of narcotics for relief. Extreme tenderness and rigidity of the abdomen may or may not be present. Stools may be bloody early in the course. Evidence of paralytic ileus with abdominal distention and constipation usually develop in a few hours. Shock is often present to a moderate degree with associated tachycardia and reduction of blood pressure. Temperature is normal early but rises as the process progresses. Leukocytosis is present in the first few hours. The presence of generalized abdominal pain which does not follow the symptom complexes of the more frequent intra-abdominal lesions should make one think of this entity. The above symptomatology in a case with extensive arteriosclerosis, a heart lesion frequently associated with peripheral emboli or the presence of polycythemia vera should likewise suggest this disease. However, the diagnosis is difficult. In only thirteen of 360 cases of mesenteric occlusion collected by Trotter was the correct diagnosis made preoperatively. Credit for a correct preoperative diagnosis in the case we are reporting goes to Dr. G. W. Nibling, one of our associates.

### PROGNOSIS AND TREATMENT

Prognosis of mesenteric vascular occlusion is extremely poor. The mortality was found to be 90 per cent in Laufman and Scheinburg's series. Prompt operation with resection of the involved intestine is the only satisfactory treatment. This should be accomplished as rapidly as possible since extensive intestinal resections are very shocking procedures. Resection should be

carried well beyond the limit of the involved intestine. When the large as well as the small intestine is involved, we believe the anastomosis should not be primary but should be accomplished by the method of Mickulicz or Lahey. This has two advantages, namely, shortening the operative time and the avoidance of placing an anastomosis with its suture line in a peritoneum where peritonitis already exists. This was the practice followed during the recent war by one of us (G. F. M.) in handling resections of the right colon with beneficial results.

If the resection is extensive and the patient survives the surgical procedure, the problem of maintaining adequate nutrition becomes paramount. Planning of postoperative treatment must take into consideration the normal function of the portions of the bowel removed as well as the portions remaining. There is very little in the medical literature which separates the functions of the jejunum and ileum except to indicate that the function of the ileum involves a continuation of the digestive process initiated in the duodenum and jejunum. The function of the first part of the colon is concerned largely with electrolyte and water absorption. There seems no reason to believe that the distal portion of the small bowel and the proximal portion of the large bowel serves any vital function which could not be taken care of by the remaining portions of the small and large intestines. The compensatory ability in the experimental animal in which there has been a drastic surgical reduction in the size of the intestinal tract seems quite remarkable (Grollman). Clinical experience would indicate the same to be true in the human. Consequently, there is reason to believe that a relatively normal digestive process will develop in the human in spite of marked reduction in size of the intestinal tract.

Dietary therapy in these cases before the bowel has had time to compensate for its drastic loss must be outlined with full realization that the products of incomplete

protein and fat digestion together with fluids and electrolyte will reach the remaining portions of the large bowel in rather large quantities. If the ascending colon has been resected, the portion of the large bowel which is normally most active in fluid absorption is absent. Furthermore the products of incomplete digestion are somewhat irritating to the colon. Consequently, a large amount of fluid plus the products of incomplete digestion pouring into an abbreviated colon produce an excellent combination for development of diarrhea with associated nutritional, electrolyte and fluid loss.

After careful consideration of the above notations the appropriate plan for dietary management suggests itself. In the early postoperative days, calories, electrolyte, fluids and vitamins should be administered parenterally. Protein requirements can be administered by blood transfusions and parenteral amino acids. After the digestive tract will tolerate oral administration of the above requirements, the diet should be arranged so that it contains the necessary calories in the form of rapidly digested carbohydrates and proteins with a minimum of fats and a low fluid content. This may be provided at first by the use of such preparations as Nutramigen.\* Vitamin supplements, such as vitamin B complex, probably should be administered parenterally for the first two or three weeks since they tend to have a laxative effect by mouth. We believe that it is best to maintain a minimum of fluid intake coincidentally with caloric intake, additional fluids being administered when the digestive tract is not primarily concerned with the process of digestion. After approximately two weeks of this regimen, other foods of a more general nature, which are easily digested and of a low fat and roughage content, may be added to the diet as the intestinal tract begins to compensate for its reduction in size. At the end of two months the compensatory process is fairly well accomplished and the patient can tolerate a

\* Provided by Mead-Johnson & Company.

fairly general diet still avoiding foods with high fat and high roughage content.

#### CASE REPORTS

A sixty-four year old male was admitted to the Shannon West Texas Memorial Hospital on January 30, 1946, as an emergency because of severe abdominal pain of six hours' duration. The pain was intermittent, had been progressive and vomiting had been present from the onset. There was no hematemesis. Pain was so intense that morphine failed to relieve until it was administered intravenously. The past history revealed that the patient had had digestive disturbance for approximately one year.

Examination revealed an acutely ill male whose abdomen showed only a moderate degree of tenderness and muscle spasm, generalized but most marked in the upper half. The heart showed no evidence of hypertrophy and on examination the rhythm was regular and there were no murmurs present. Peripheral arteriosclerosis of a marked degree existed. On admission his temperature was 98.4°F., pulse 84, respiration 20 and blood pressure 120/64. Laboratory studies revealed a hemoglobin of 82 per cent, red cells 5,500,000, white cells 22,700, 10 stabs, 86 segmented and 4 lymphocytes. Urinalysis showed a trace of albumen, otherwise normal. An electrocardiographic tracing showed a low impulse in all leads but was otherwise normal. General supportive measures were given. In a few hours it seemed obvious that the patient had a surgical condition of the abdomen and a laparotomy was performed within twenty-four hours after the onset of abdominal pain. Shortly before the patient was taken to the operating room he developed auricular fibrillation which was treated by parenteral digitalis therapy.

Under endotracheal cyclopropane anesthesia through an upper abdominal midline incision, the abdomen was opened and several loops of gangrenous bowel was seen. The involved area of intestine was sharply demarcated at the hepatic flexure of the colon and proximally involved the entire ileum and all but four and a half feet of jejunum. The mesentery was edematous and the vessels showed no evidence of pulsation throughout this involved area. The right colon and all but 54 inches (as measured postoperatively by x-ray) of the small intestine were removed. A jejunotransverse colostomy

after the method of Lahey was accomplished bringing the two limbs to the surface through a right subcostal incision. Ten days post-operatively two curved clamps were applied to the spur of the jejunotransverse colostomy and a large rubber tube sutured into the jejunal limb to keep the skin about this area clean. The clamps fell off in seven days. The patient was allowed to be up and approximately four weeks later the jejunotransverse colostomy was closed. X-ray examination eight weeks post-operatively revealed barium entering the transverse colon two hours after oral administration. After twenty-four hours a small amount of barium remained in a greatly dilated stomach. He was discharged from the hospital one week later and approximately one month after discharge resumed light work.

During his postoperative course his heart remained under satisfactory control by the use of parenteral digitalis. Auricular fibrillation continued for approximately two weeks, at which time the patient developed a regular rhythm again and digitalis therapy was discontinued.

Dietary management was essentially as given above. Supplemental parenteral fluids, vitamins, electrolyte and nutrition were required because of the marked loss of fluids through the jejunocolostomy opening. Following jejunotransverse colostomy closure the entire needs of the patient were provided by mouth. Stools of liquid and soft nature averaged from two to four daily. Since leaving the hospital the patient has been uncooperative in regard to his dietary management, eating fresh vegetables of high roughage content, pork and any other food he desired. He still has two to six liquid to soft stools daily. He has continued vitamin supplements by mouth. We believe that this lack of cooperation on the part of the patient in regard to his dietary instructions, associated with no increase in digestive disturbance is definite evidence of remarkable ability of the gastrointestinal tract to compensate for drastic reduction in size.

Although we have not started vitamin E therapy, the report of Pappenheimer and Victor is suggestive of its value in preventing "ceroid" deposits and possible hepatic cirrhosis in nutritional disturbance resulting from loss of function of a large amount of intestinal tract.

The pathologic findings were as follows: More than fifteen feet of small intestine plus the



FIG. 1. Photograph of patient ten weeks postoperatively showing a 10 foot 2 inch Miller-Abbott tube passed through the patient and extending one foot from the nostril and anus.

right colon were examined. There was marked congestion and discoloration of the tissues having gross appearance of gangrenous intestine. Microscopic examination revealed considerable congestion and hemorrhage plus marked degenerative change.

#### SUMMARY AND COMMENTS

The case reported above, so far as we know, is the first on record in which a successful removal of all but 54 inches of the small bowel plus the right colon has been successfully accomplished for superior mesenteric occlusion. (Figs. 1 and 2). Although Elman and Read successfully removed half the colon and all of the small intestine but three feet of jejunum, their patient was suffering from inflammatory disease of the intestinal tract, apparently regional ileitis, and no superior mesenteric arterial throm-



FIG. 2. Roentgenographic study of patient with Miller-Abbott tube in place as shown in Figure 1, showing one loop of small intestine remaining.

bosis. Furthermore, the extensive resection in their case was accomplished in two different operations nine days apart. Their case, however, lends further support to our observation in regard to the remarkable compensatory ability of the human for the loss of a large portion of the intestinal tract.

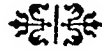
The etiology in our case was probably arteriosclerosis of the superior mesenteric artery. There were no pathognomonic signs or symptoms present for the condition; however, the disproportion between severe pain and moderate degree of abdominal spasm and tenderness was suggestive. Resection of the involved segment of small intestine and right colon was accomplished after the method of Lahey. The jejuno-transverse colostomy was later closed. The postoperative nutritional problems resolved themselves into maintenance of appropriate fluid, mineral, vitamin and nutritional balance which were accomplished parenterally at first and later by mouth. Oral feedings were increased following jejunocolostomy closure and development

of compensatory adjustment of the intestinal tract. The patient's condition four months postoperatively is good with gain in weight and without evidence of fluid and electrolyte imbalance, in spite of failure by the patient to cooperate in regard to dietary instructions.

We are deeply indebted to Drs. L. Dragstedt, M. Comfort, J. Clagett, A. Grollman and E. Ogden for their helpful suggestions in regard to postoperative management of this case.

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MANY conservative operations on the blood vessels have been marred by functional failure, a physiological fault rather than an operative imperfection. This is due to thrombus formation occurring on the damaged intima and spreading peripherally to affect the collateral vessels.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).

# OSTEITIS PUBIS FOLLOWING SUPRAPUBIC PROSTATECTOMY

## RESULTS WITH DEEP ROENTGEN THERAPY

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SINCE the publication of a paper on this subject by the senior author in 1938, four additional cases have been encountered. Ten cases in all have thus been observed by us and this has convinced the authors that this complication is much more frequent than has been reported. The first description of this syndrome by Dr. Edwin Beer in 1924 described most of the facts that are known about this entity. Since 1938 very few references have appeared in the literature. Muschat, in 1945, reviewed the literature and has reported a total of twenty-three cases following suprapubic cystotomy. (The two cases reported by Pierson in 1939 should be added to this total.) Cohen, in 1946, found a total of thirty-three cases of osteitis pubis, but this total undoubtedly included cases of osteitis pubis that did not follow suprapubic cystotomy but followed other surgical conditions. His two cases followed suprapubic prostatectomy.

The purpose of this publication is to call attention again to this rarely reported condition, to emphasize the success we have obtained with deep roentgen therapy and to give a biopsy report of a section of bone removed in one of our cases. A biopsy report has been described only three times previously by Pierson, Silver and Muschat. Two other cases were studied at autopsy, one by Wheeler which has not been fully reported in the literature, and one by Pierson.

### CASE REPORTS

CASE 1. A. G., (7063) age fifty-seven, was admitted to the Sinai Hospital November 2,

1940, with a six-months' history of pain and difficulty in voiding. This was associated with frequency, poor stream and some dribbling. Physical examination was essentially negative except that on rectal examination the prostate was slightly elevated. It was soft, doughy and elastic in consistency with no areas of stony hardness suggestive of malignancy. Cystoscopy revealed 500 cc. of residual urine. There was marked intravesical bulging of the prostate, both lateral lobes of which continued on into the urethra. There was very little median lobe bulging. Many trabeculations and cellules were present. Roentgenogram examination was negative except for evidence of a markedly distended bladder. The impression was benign prostatic hypertrophy, second degree. A two-stage suprapubic prostatectomy was performed on November 5, 1940, and November 19th, together with partial bilateral vasectomy and partial resection of the tunica vaginalis for small hydroceles. A suprapubic drain was utilized in the first stage but not in the second stage. A gauze drain was placed in the bladder at the second stage. On November 27th, the patient voided.

Four days later (twelfth postoperative day) he began complaining of pain in the right inguinal region and also of pain on abduction and extension of the right leg. Some tenderness was present in the region of the right groin. It was our impression that we were dealing with osteitis pubis. Subsequent recovery was uneventful and the patient walked without difficulty or pain when discharged from the hospital on December 18th.

After one week at home, the pain in the pubic region, groin and right leg returned. He soon developed pain in the right kidney region. Associated with the pain was urinary frequency, dysuria and fever. The urine contained many white and red blood cells, and the diagno-





FIG. 1.

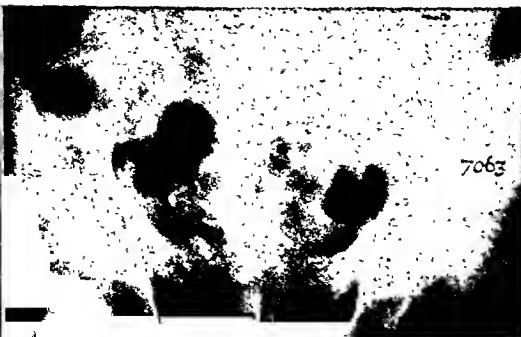


FIG. 2.



FIG. 3.

FIG. 1. Case 1. A. G. Roentgenogram of pelvic bones before operation; normal.

FIG. 2. Case 1. A. G. Roentgenogram eight weeks after prostatectomy shows roughening and irregularity of the ascending ramus of the pubis on the right side. Diagnosis: osteitis pubis.

FIG. 3. Case 1. A. G. Roentgenogram seven months after prostatectomy shows bridge of calcification in pubic bones; stage of healing after course of deep roentgen therapy.

sis of pyelonephritis, right, was made. A course of sulfathiazole caused the temperature to return to normal in several days. The pain in his pubic region and thigh persisted. The possibility of malignancy, secondary to the prostate, was considered. The acid phosphatase was 1.6 King-Armstrong units. The initial roentgenogram (January 24, 1941) of the pelvis was reported as "pelvis shows roughening and irregularity of the ascending ramus of the pubis on the right side. These changes suggest the possibility of metastasis." The patient was then put in a plaster cast for one month without results. A course of deep roentgen therapy was then started with much improvement. The pelvis was again x-rayed on February 24th and the "pelvis shows marked separation of the symphysis with destruction of the right symphysis and probably destruction of the left os pubis. Metastasis should be ruled out. This separation of the symphysis was not present on January 24, 1941." On March 4th a biopsy of the pubic bone was taken. Grossly, the bone was found to be of softer consistency than normal. According to the microscopic report (Dr. T. Weinberg) sections of the bone showed the presence of a loose, cellular, connective tissue within the marrow spaces. This was infiltrated with polymorphonuclears and lymphocytes as well as a few histiocytes. Some of the bony trabeculae showed irregular margins. Diagnosis: Fragments of bone showing histologic picture compatible with the diagnosis of osteitis. A roentgenogram was again taken on March 26th

and this showed "some atrophy of the symphysis and os pubis with regeneration of bone. The changes in the pubis suggest that we are dealing with an inflammatory lesion rather than a malignancy." The patient was discharged on March 20, 1941. Thereafter he steadily improved and after three or four months he did not limp any longer. The roentgenogram then showed some calcification where previously there was an area of necrosis. (Figs. 1, 2 and 3.) He was again x-rayed in March, 1944, and the pelvic bones were found to be in good condition.

CASE 11. M. S. H., (7437) age sixty-three, was seen on January 19, 1942. For six years previous to this time, he complained of nocturia and dribbling at the end of micturition. Seven days before admission to the Sinai Hospital, he was inebriated and since then he has had acute retention and difficulty in voiding. He also had marked urgency. Repeated catheterization was necessary and on admission an indwelling catheter was utilized. Physical examination was essentially negative except that on rectal examination, the prostate was found to be definitely enlarged, uniformly throughout with the median furrow obliterated. The prostate was of a soft, doughy, elastic consistency with no areas of stony hardness suggestive of malignancy. The seminal vesicles were normal in size and consistency. Cystoscopy showed marked intravesical bulging of the prostate, right and left lateral. There was moderate bulging of the prostate into the urethra. Many trabeculations and cellules were present. No diverticuli, stones or tumors were present.



FIG. 4.



FIG. 5.



FIG. 6.

FIG. 4. Case II. M. H. Roentgenogram eight weeks after prostatectomy; some indefinite roughening of ascending ramus of the pubis; symptoms and signs of osteitis pubis.

FIG. 5. Case II. M. H. Separation and irregularity of symphysis pubis eight months after operation; symptoms of osteitis pubis.

FIG. 6. Case II. M. H. Separation of symphysis; healing process present after course of deep x-ray therapy; disappearance of all symptoms and signs.

The impression was benign prostatic hypertrophy, third degree. When the catheter was removed, he developed an acute retention with a 475 cc. residual urine. A two-stage suprapubic prostatectomy and a partial bilateral vasectomy was performed on January 27th and February 6, 1942. A suprapubic tube was utilized. On the operating table the patient had a bowel movement which contaminated the scrotum but not the suprapubic wound. On February 19th, the patient did not void and an unsuccessful instrumentation necessitated the direction of a sound through a vesicoprostatic canopy by means of a finger placed in the bladder. A catheter was then placed *in situ*. On December 27, 1942, the catheter was removed and the patient voided. The patient was discharged on March 3rd, voiding well but complaining of some pain in the region of the left groin and also during abduction of the left leg. Roentgenogram of the symphysis pubis was not definite for osteitis pubis though this complication was considered.

Since his discharge he complained of pain radiating down both legs, worse on the left, aggravated by abduction but relieved by adduction. A roentgenogram of the pelvis showed slight separation of the symphysis pubis. Slight bone changes were present in the superior aspect of the symphysis. The left symphysis showed some bony rarefaction. The pain was exquisite and walking was impossible. On May 23, 1942, a cast was applied. On June 8th a trophic ulcer developed on the sacrum and the next day the cast was changed. The pain nevertheless persisted making it necessary for frequent injections of morphine for relief.

On July 8th, a course of deep roentgen therapy was instituted (eight treatments). This resulted in considerable subjective improvement. The patient was finally discharged on October 22nd after graded exercising. (Figs. 4, 5, and 6.) He was then able to walk with crutches. He was seen on August 5, 1943, at which time he was walking well.

CASE III. B. R., (D. C., U-38000) age fifty-seven, was admitted to the Sinai Hospital with a nine-month history of incontinence with some remissions. The patient complained of pain in the back which became progressively more severe during the ten days prior to admission. The pains were sharp and over the loins. He felt very weak and was confined to bed. Physical examination on admission revealed an enlarged heart with a systolic murmur in the aortic area and an enlarged liver. The bladder was 5 cm. above the symphysis pubis. Bilateral costo-vertebral angle tenderness was also present. Rectal examination revealed the prostate to be uniformly enlarged, soft, doughy and elastic in consistency, with a small nodule on the right lobe but not suggestive of malignancy. The patient was catheterized on admission and 700 cc. of cloudy urine was obtained. The temperature was 104°F., the urea 76 Gm. per cent and the white blood count 16,800 with 87 per cent neutrophils. A roentgenogram of the chest on admission showed infiltration of the right base due to unresolved pneumonia. This cleared on sulfadiazine and penicillin therapy.

Cystoscopy was then performed and a large intravesical protrusion of the left postero-lateral part of the prostate was found, with some protrusion of the right lateral lobe. Intra-



FIG. 7. Case III B. R. Irregularity of right symphysis; symptoms and signs of osteitis pubis nine weeks post-prostatectomy.



FIG. 8. Case III. B. R. Bridge of calcification across symphysis pubis; stage of healing after course of deep roentgen therapy; disappearance of all symptoms and signs.

urethrally, there were two large lateral lobes which met in the midline closing the urethra. The trigone was hypertrophied. The bladder mucosa was injected and there were trabeculations and cellules present. There was no evidence of a stone, tumor or ulceration. A diagnosis of benign prostatic hypertrophy, second degree was made. The patient had also complained that the calf of the right leg was very tender. He was seen in consultation by the surgical staff and a diagnosis of thrombophlebitis was made and bilateral femoral vein ligation was recommended. This was performed on September 26, 1945.

A two-stage suprapubic prostatectomy was performed on October 6th and October 17, 1945, together with a partial bilateral vasectomy. On October 19th dehiscence of the operative site occurred and a secondary closure was attempted. The wound soon broke down and thereafter it healed by granulation. On December 16th the catheter was removed but the patient failed to void. Dilatation was attempted but an obstruction was met at the vesical neck. Incontinence developed and the patient drained suprapubically. Under sodium pentothal anesthesia the patient was dilated up to No. 26 French and a No. 18 Foley catheter was inserted. He closed suprapubically on December 25th. On December 27th the patient began complaining of severe pains in the lower limbs and he could not abduct his legs. It was thought that osteitis pubis had developed. An x-ray (Fig. 7) was taken revealing that "the right symphysis appears to be irregular in outline. An osteitis should be ruled out." Deep roentgen therapy was instituted and the patient responded well.

Following the third deep roentgen treatment, the suprapubic wound broke down. A Foley catheter was again inserted. After six roentgen treatments he was relieved of all symptoms and pain in his extremities. (Fig. 8.) The suprapubic wound was curetted and the wound thereafter closed. Following this he began to void well with good control and no incontinence. On February 15, 1946, he was discharged from the hospital as cured, and was able to walk perfectly well. A follow-up roentgenogram on March 29th reported the "osteitis previously described was no longer demonstrated."

CASE IV. S. S., (8889) age sixty-four, was admitted to Sinai Hospital on January 10, 1946, with a history of frequency and dribbling following urination of four years' duration. He also had nocturia four times, hesitancy and a weak stream. For these complaints he was placed on 2 to 3 mg. of stilbesterol daily for one year. This improved his stream but resulted in the development of bilateral gynecomastia. The stilbesterol was then discontinued and the stream once again became weaker. He has also been troubled for many years with backaches. These aches have dated back to an injury which he received to the lower end of the spine about forty years previously. This area was again insulted when he was struck by a street car in 1910 resulting in the dislocation of his right hip. During the past eighteen months he has been treated for generalized arteriosclerosis with intermittent claudication. This was usually relieved by diathermy.

Physical examination on admission was



FIG. 9. Case iv. S. S. Urethrogram showing complete obstruction at the prostatic urethra; no evidence of osteitis pubis.



FIG. 10. Case iv. S. S. Roentgenogram four months after prostatectomy, also several weeks after course in deep roentgen therapy; demonstration of ankylosis of symphysis pubis; disappearance of symptoms and signs.

essentially negative except that a large saddle hernia in the right groin, a hydrocele of the right cord and bilateral varicosities of the legs were present. Rectal examination revealed a tight external sphincter, internal and external hemorrhoids, and a prostate that was uniformly enlarged, soft, doughy and elastic in consistency. The median furrow was obliterated. There were no hard nodules present suggestive of malignancy. Cystoscopy revealed slight bulging of the right and left lateral lobes of the prostate and a definite median lobe posteriorly. No evidence was found of a stone or tumor mass in the bladder. Many trabeculations and some cellules were present. No diverticuli were seen. There was only slight bulging of the prostate in the urethra. The impression was benign prostatic hypertrophy, second degree.

A two-stage suprapubic prostatectomy, hydrocelectomy and partial bilateral vasectomy was performed on January 11th and January 18, 1946. The prostate was rather fibrous but was bulging into the vesical orifice and into the prostatic urethra. This was removed in two sections, the right being larger than the left lobe. During the interval between the two operations the patient complained of pain in the legs below the popliteal space. A diagnosis of peripheral vascular disease was made by the surgical consultant and tetrathione and intermittent venous occlusion was recommended. On the fourth postoperative day following the second stage, the prostatic packs were removed and the patient bled excessively but this was soon controlled. On January 30, 1946, he was permitted to sit up on the side of the bed, but started to complain of tenderness, redness, swelling and pain in the left leg. The impression

was that the patient had developed phlebotrombosis and early thrombophlebitis. From January 31st to February 1st the patient voided on several occasions up to about 125 cc. Thereafter he was unable to void and continued to drain suprapubically. Attempts at dilatation were unsuccessful even under sodium pentothal anesthesia.

A cystourethrogram (Fig. 9) was taken on February 7th, with the aid of a clamped catheter placed into the bladder through the suprapubic fistula. This film revealed complete separation of the bladder from the urethra at the prostatic cavity, the obstruction being just below the level of the vesical orifice. A suprapubic cystotomy was performed on February 8th and this revealed the complete obstruction at the vesical neck. The obstruction consisted of complete overgrowth of the bladder mucosa over the vesical orifice. The site of the vesical orifice was revealed by a slight depression 5 mm. deep. The obstruction was broken through over a sound placed in the urethra and the vesical orifice was dilated up to No. 28 French, and a No. 18 Foley catheter was inserted into the bladder through the urethra. On February 13th, he began to complain of pain in his legs and thighs. Despite the previous history of backaches, the syndrome strongly suggested osteitis pubis. On February 16th, the catheter was removed and he voided for two days, at the end of which time the suprapubic wound opened again and drained profusely. A Foley catheter was again inserted. On February 21st, the catheter was removed and he again voided well but in small quantities. Nevertheless, the suprapubic wound continued to drain profusely. At this time he also

developed a vasitis. A cystoscopic examination was then performed on February 26th and a vesical calculus was found and removed. Thereafter he continued to improve steadily and voided well without incontinence, but frequently and in a good stream. He was discharged from the hospital, returned home and advised to undergo a course of deep roentgen ray therapy. This he did, receiving a course of eight treatments. A flat film of the pelvis was then taken on May 6th and it showed a bridge of calcification connecting the two pubic bones, causing an ankylosis of the symphysis pubis, evidence of a healing osteitis pubis. (Fig. 10.) Since he received his deep roentgen treatments, his condition has changed from being bed-ridden to being able to get about with the aid of a cane. At present his condition is steadily improving and when last seen he was walking without the aid of a cane.

It appears from a review of the literature on osteitis pubis that this condition follows: (1) some trauma to the symphysis and pubic bones and (2) infection of the traumatized areas. The trauma causes a devitalization of the tissues and a superimposed infection comes from a very accessible source—the perivesical area—potentially infected by the urine following suprapubic cystotomy. Osteitis pubis almost always follows suprapubic prostatectomy, but some cases have been reported following other surgical conditions, namely, by Pierson, Barnes, Soderlund, Jentzer and Kleinberg. In the cases reported by Pierson, osteitis pubis followed (1) an infected herniorrhaphy which had drained for five years and finally, before operative cure, became a suprapubic urinary fistula, (2) after trauma to the lower abdomen with the development of a pre-vesical abscess, which after incision persisted as a suprapubic sinus and (3) the creation of a devitalized area forming a nidus for infection in the case of trauma to the lower abdomen. Wilensky states that "infections in the osseous tissues is aided by injury to the periosteum or to the bone." Barnes reported a case of osteitis pubis which followed a perineal prostatectomy during which procedure instrumental maneuvers produced "injury to the an-

terior prostatic urethra and opened into the space of Retzius." Similarly in the case reported by Soderlund following a vaginal delivery, trauma to the pubis can be understood, and the presence of a small sinus which led from the vagina to the pubic bone fulfilled the two conditions needed as a prerequisite for osteitis pubis. In Jentzer's case, pubic pain and tenderness developed two weeks after symphysiectomy for a difficult delivery. About five months after the delivery there was a suprapubic discharge and the roentgenogram showed separation of the symphysis with destruction and the presence of a small sequestrum. Operation resulted in recovery. A third female reported to have suffered from osteitis pubis was reported by Kleinberg. This appeared to result from "a metastatic bone infection, the source being pyelonephritis." She also experienced chills and fever and had infected urine. Clinically and roentgenographically, she had the findings of osteitis pubis. Thus, though osteitis pubis follows almost exclusively after suprapubic prostatectomy, it nevertheless is not entirely confined to the diagnostic acumen of the urologist.

The two prerequisites of pubic trauma and infection are present in many cases in which suprapubic prostatectomy has been performed, but the reason for its occurrence in some and not in others in which apparently the same conditions existed has not as yet been answered.

Wheeler attempted to prove Beer's hypotheses of trauma and infection by his experimental work on rabbits. He utilized trauma plus either (1) sterile urine, (2) *Staphylococcus aureus hemolyticus* culture, (3) mixed culture and repeated trauma and (4) foreign body and staphylococcic infected urine, both of which were placed under the periosteum. In these experiments no evidence of osteitis pubis was present in any of the rabbits.

The condition of osteitis pubis is most frequently evident about three weeks following the operation, but may begin any time from two weeks to two months later. The diagnosis can usually be made by the

marked abductor spasm of both legs. This causes the patient excruciating pain when any attempt at movement is made or even when the bed is jarred. The only movement permitted is adduction of the limbs. The diagnosis is established by the x-ray where one observes separation of the symphysis with fluffiness of the periosteum. Later osteoporosis is evident. After healing occurs the roentgenogram frequently shows osseous ankylosis at the symphysis pubis.

Osteitis pubis must be differentiated from simple prevesical space infection without bone involvement. Roentgenogram of the pubis will readily demonstrate this. A distinction must also be made between it and a true osteomyelitis of the pubic bone. In the latter condition the focus causing the "extension osteomyelitis" may be found and also the temperature remains elevated and sequestration occurs. A most important differential diagnosis must be made from that of metastatic involvement of the pubis. When the periostitis first becomes apparent clinically following prostatectomy, the surgeon is very apt to wonder whether the prostatic hypertrophy may not be accompanied by a carcinoma of the gland. Later, when absorption is observed in the roentgenogram, his suspicions are further aroused. In osteitis pubis, however, the osteoporosis is not accompanied by osteosclerosis, which does occur in prostatic metastasis of bones. When nodules are present fibrosarcoma has to be ruled out.

Pathologically, the diagnosis is substantiated by the examination of curettings which show a subacute osteomyelitis. Kleinberg states that the pathological condition varies from a simple periostitis to an extensive bone lesion with necrosis of the bone and cartilage and subsequent healing. Wilensky also stated that with roentgen examination "in the absence of a malignant condition, the diagnosis can be definitely made of an inflammatory lesion." Muschat states that his microscopic studies compels one "to accept the theory of bone inflammation." Pierson performed a biopsy on one of his patients, the pathological

report being chronic inflammatory tissue. The biopsy report on Silver's case showed cartilage and fibrous tissue with non-specific acute inflammation. The patient in the autopsy case reported (Pierson) died of general septicemia. This septicemia developed following suprapubic prostatectomy. The osteochondritis reported here was secondary to an "abscess in the space of Retzius which had eroded the pubic bone and completely destroyed the cartilage of the symphysis pubis.

In addition to our previous views relative to the etiology, we believe that a contributing factor is trauma to the posterior surface of the symphysis pubis at the time the enucleation of the prostate is performed. Frequently, in order to break the mucous membrane superiorly at the vesical orifice, marked pressure against the pubic bones is necessary, causing this area, because of trauma, to be exposed to infection from an already infected urine. From the above thought, it is questionable whether the enucleation should not be started inferiorly rather than superiorly.

In our first case of this series, a biopsy of the infected area was taken, and this plainly illustrated the inflammatory reaction which was taking place in the bone. This, too, substantiated the impression that osteitis pubis is an inflammatory condition. Wheeler, on the other hand, is of the opinion that osteitis pubis is the result of an injury to the nerves, an atrophoneurosis. He reported an autopsy which showed no inflammatory process but an atrophy of the cellular elements of the bones. He classified osteitis pubis as another form of Sudeck's atrophy, a self-limiting bone atrophy which was originally reported by Sudeck in 1900.

The prognosis of osteitis pubis is good. Relief is evident after a varying period, up to two years later in Kretschmer's case. In healing the symphysis and cartilage become ossified and the pubic bones fused. The only residuum as a rule is a symptomless ankylosis of the pubic bones.

Therapy to obtain quicker relief has varied from heat and massages, diathermy



and complete rest to immobilization of the pelvis by a body cast. Penicillin and sulfa drugs have also been tried without any noticeable improvement. In the authors' hands, deep roentgen ray therapy has given excellent results in bringing about a marked acceleration in the relief of the pain. In our first case traction was utilized for about one month without beneficial results and a course of deep x-ray therapy resulted in improvement. In our second case, the application of a course of deep x-ray therapy brought about rapid relief where repeated applications of a plaster cast for months had failed. In our third case, deep x-ray therapy was instituted immediately on making the diagnosis and soon thereafter good therapeutic results with the relief of pain and abductor spasm was evident. In our fourth case after a course of deep roentgen ray therapy, a bedridden patient was once again able to walk. This patient is still under observation.

The deep therapy that we have utilized is as follows: In Case I, on the left hip anteriorly using a composite filter 200 KV; 20 MA; 50 skin target distance on a 15 by 15 field, 2020 R units; over a period of one month. The lateral field received 1820 R units over a period of one month. The posterior field received 1030 R units from January 20, 1943 to August 10, 1944, inclusive. In Case II, the symphysis on the anterior field received 2435 R units with a composite filter; 200 KV; 20 MA; 50 skin target on a 10 by 10 field. This was given from January 30th to May 7, 1941, inclusive. The posterior area of the symphysis received 2200 R units on a 15 by 15 field from February 7th to May 9, 1941, inclusive. In Case III, the patient received in all 6668 R units with a 200 KV; 20 MA; 50 skin target distance with a composite filter equivalent to 2 mm. copper on a 10 by 10 field over the symphysis pubis anteriorly. The treatments were given from January 3rd to January 22, 1946, inclusive. The above roentgen therapy was given by the attending radiologist, Dr. Marcus Ostro. In Case IV, a course of eight treat-

ments were given by Drs. Christie, Groover and Merritt.

#### SUMMARY

1. Four additional cases of osteitis pubis following suprapubic prostatectomy are reported.
2. Osteitis pubis occurs most frequently in the third week postoperatively but can occur at any time from two weeks to two months postoperatively.
3. Pathologically, osteitis pubis is a bone inflammation, and microscopically shows subacute inflammation.
4. Osteitis pubis has as its prerequisite trauma to the pubic area and infection.
5. Starting the enucleation of the prostate superiorly as well as retraction against the symphysis pubis may contribute to pubic trauma.
6. The diagnosis is made by the inability of the patient to abduct the legs without pain and roentgen evidence of osteoporosis, fluffiness of the periosteum and separation of the symphysis pubis.
7. The prognosis is always very good but over a long period of time.
8. Treatment by deep roentgen therapy causes marked and rapid amelioration of the symptoms.

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# BENIGN TUMORS OF THE STOMACH\*

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THERE are complicating opinions in the literature concerning the frequency of leiomyoma of the stomach. The differences in frequency apparently arise from the opinions of clinicians as against the findings of pathologists. The

in benign tumors of the stomach is frequently encountered. Percentages vary from 59 to 75 per cent. The symptoms are usually those of dyspepsia of many months' duration, sometimes associated with bleeding of varied degree. The treatment of these



FIG. 1. Gastrointestinal series showing large filling defect in lesser curvature of stomach from pressure of a large tumor mass with calcification (arrow).



FIG. 2. Gastrointestinal series showing area of calcification (upper arrow) and pressure on proximal jejunum (left arrow).

majority of cases of leiomyoma of the stomach that have been reported are those in which the patients were treated surgically, while cases in which the patients showed no signs or symptoms have usually gone unreported. Similarly, these lesions are infrequently detected in gastrointestinal series because the large majority of these tumors are less than 1 cm. in diameter. Finesilver, of the New York Hospital, reports an estimated 43,200 gastrointestinal x-ray series taken in the course of eight years, of which only six showed benign tumors. Other clinics report similar findings. Malignant change or degeneration

patients is surgical and is generally satisfactory and the mortality is low.

Meissner reports a series of fifty autopsies selected at random in which it was possible by careful examination to find one or more benign tumors of the stomach in twenty-three of the fifty specimens examined. A total of forty-four tumors was found in the fifty stomachs. The number found in the individual stomach varied from one to six, eleven stomachs having more than one and two having six. The tumors were somewhat more common on the anterior wall and were most frequent in the fundus, especially near the cardia. The size of the tumors varied up to .7 cm.

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FIG. 3. Barium enema showing pressure filling defect in transverse colon near splenic flexure.



FIG. 4. Postoperative gastrointestinal series showing normal filling of stomach and duodenum.

in greatest diameter. The most common size was between .4 and .6 cm. in diameter. This author compares the incidence of leiomyoma of the stomach to that found in the uterus, estimated by Klob to be 50 per cent in women over fifty years of age.



FIG. 5. S. P., No. 51197; gross photograph of abdominal tumor mass; fibroleiomyoma with malignant change. The mass weighed 500 Gm. and measured 15 by 9 by 7 cm. at its largest diameter. Microscopically, the tumor was composed in part of blue-stained fibrous tissue and in part of red-stained smooth muscle fibers. In places the tumor cells were spindle-shaped and the nuclei were small; in other areas, the spindle-shaped cells were large with large hyperchromatic nuclei which varied in size and shape with a moderate number of mitotic figures. The tumor showed considerable degenerative change with hemorrhage, edema and defect formation.

#### CASE REPORT

A. S., a sixty-one year old white female, was admitted to the hospital on June 6, 1946, with the complaint of a feeling of fullness after eating not associated with vomiting. There was a weight loss of about 25 pounds in the past three months. Her general health was good. She had two children aged thirty-three and thirty-five years. Physical examination revealed the presence of a hard, firm, irregularly shaped mass measuring 15 by 15 cm. in the left epigastrium. This mass was partially moveable and not tender. Blood and urine studies were negative. The remainder of the examination was not remarkable. Preoperative x-ray examination disclosed the presence of a large tumor mass pressing upon the lesser curvature of the stomach, the transverse colon and the proximal jejunum. (Figs. 1, 2 and 3.)

The patient was operated upon under spinal anesthesia and an exploratory laparotomy was performed. Upon opening the abdomen a large, solid and partially cystic mass was found intimately adherent to the posterior wall of the stomach, the first portion of the jejunum, the transverse colon, omentum and root of the mesentery. By means of careful, sharp and

blunt dissection and separation of the leaves of the mesentery, the mass was dissected free from its attachments. During the dissection the portion of the posterior wall of the stomach was removed and a small rent was made in the jejunum. These openings were sutured with a double roll of continuous and interrupted sutures. One wide Penrose drain was left to drain the pancreatic area and the abdomen was closed in the usual manner. Pathologic examination revealed this mass to be a fibroleiomyoma with malignant change, 15 cm. in diameter.

The postoperative course was uneventful and the patient was discharged from the hospital on the fifteenth postoperative day. A gastrointestinal series taken at this time revealed a widely dilated stomach with poor peristaltic waves. A repeat gastrointestinal series (Fig. 4) performed six months later revealed the following findings: The esophagus was normal. The stomach was in normal position and had excellent peristalsis throughout. The surface of the lesser curvature in the midportion of the stomach was still slightly irregular but the mucosal pattern was excellent. The duodenal bulb was normal. This gastrointestinal series

showed an excellent recovery without permanent change after the removal of the tumor.

This patient received postoperative x-ray therapy, 4,200 R. to the abdomen and to date is entirely symptom-free.

#### SUMMARY

We have presented an unusual case of tumor of the stomach with the patient presenting a very gratifying postoperative result. The clinical and pathologic findings are listed in detail, as well as x-ray photographs before and after operation.

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# RETICULUM CELL SARCOMA OF THE ILEUM\*

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GALL and Mallory<sup>2</sup> in their classification of malignant lymphomas indicated that, based on their observations, reticulum cell sarcomas should be divided into two types: (1) stem cell lymphomas, tumors made up of highly undifferentiated presumably pluripotential cells called stem cells by them and (2) tumors made up of well differentiated cells resembling normal clasmatocytes or normal lymphocytes, the cells being smaller than the stem cells but larger than lymphocytes.

Thus, their<sup>2</sup> division of malignant lymphomas into seven categories, the first two being stem cell lymphomas and clasmatocytic lymphomas, represent subdivisions of "reticulum cell sarcoma." The other five categories are lymphoblastic lymphoma, lymphocytic lymphoma, Hodgkin's lymphoma, Hodgkin's sarcoma and follicular lymphoma. Reticulum cell sarcoma of the small intestine appears to be encountered rather infrequently. In a histological survey of malignant lymphomas at the Massachusetts General Hospital over a twenty-year period, Gall and Mallory<sup>2</sup> reported on a group of seventy initially localized malignant lymphomas, one clasmatocytic lymphoma of the ileum. The lymphoma's duration was 0.3 years, its distribution local and apparently the diagnosis was made at autopsy.

In reviewing the literature of the past ten years, reports of only two patients with reticulum cell sarcoma of the small intestine could be found although several involving the stomach were reported. Dinsmore and Ancona<sup>1</sup> reported a case of reticulum cell sarcoma of the jejunum in a fifty-eight year old woman. Resection of the involved jejunum was performed followed by irradiation. The length of survival

was not reported but in view of the involvement of mesenteric lymph nodes the outcome was doubtlessly fatal.

Reticulum cell sarcoma of the ileum was the diagnosis in a case<sup>1</sup> presented at one of the weekly clinico-pathological exercises at the Massachusetts General Hospital. A two-stage operation, resecting the terminal ileum and ascending colon, was performed. Following operation, intestinal obstruction and a fecal fistula developed. Death ensued ten weeks after operation and was thought by the operating surgeon to be due to inanition as a result of the fistula which three attempts failed to isolate and close.

## CASE REPORT

J. M. N., a white male, aged sixty, was admitted to the hospital on July 26, 1945. On admission he gave a history of attacks of cramp-like generalized abdominal pain lasting one or two hours. The first attack occurred March 18, 1945, and others followed fairly frequently. Ingestion of food appeared to precipitate the attacks and at such times vomiting of ingested food occurred. Bowel habit changes consisted of difficulty, straining and passing of small stools. No melena was noted. Moderate weight loss had occurred.

There were no symptoms relative to the respiratory system. Occasional ankle edema was noted. The urological symptoms showed moderate nocturia, dysuria at the end of urination, a small stream with abrupt stopping and incontinence sufficient to cause wetting of the underclothing. The family history was not relevant. A history of untreated chancre in 1920, and many attacks of gonorrheal urethritis was elicited. His last service in the tropics was in February, 1945.

The physical examination revealed an obese, stocky male not acutely ill. His head and neck were normal. The sclerae had an icteric tinge

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FIG. 1. The bowel has been opened to demonstrate the lesion. Note the difference in the diameters of the ileum and colon.

and the conjunctivae were slightly injected. The patient was edentulous. The heart and lungs were negative on physical examination. The blood pressure was 126/94. On examination of the abdomen there was no rigidity. It was thought that the liver was either enlarged or that a mass could be palpated in the liver area which was not tender. There was tenderness in the lower abdomen but no masses could be felt. Rectal examination was negative except for a moderate enlargement of the prostate. The temperature chart showed a daily afternoon rise of 0.4°C. to 0.8°C. The pulse rate ranged between 70 and 90; the respiratory rate between 18 and 24.

Urinalysis showed no pathological findings. There were 7,500 white cells with a differential count of 75 neutrophils, 3 eosinophils, 1 basophile and 21 lymphocytes. The hemoglobin was 15 Gm., while the blood Kahn and Wassermann tests were negative. The icterus index was within normal limits. The prothrombin time was 16 seconds with 60 per cent prothrombin activity. The blood sugar was within normal limits. The total proteins were 7.28 Gm. with an A/G ratio of globulin, 2.17 Gm., albumin, 5.11 Gm. The N.P.N. was 41.4 mg. and the plasma chlorides were 42.0 mg. Gastric analysis revealed the absence of free hydrochloric acid.

Repeated stool examinations were positive for occult blood. Numerous *Trichomonas hominis* cysts and *Trichocephalus trichiura* ova were found. No amebae could be found in the stools and the complement fixation test for amebiasis was negative.

Roentgenograms of the heart and lungs

showed no abnormalities. In spite of frequent x-ray studies of the gastrointestinal tract the only positive findings were a narrowing of the terminal ileum interpreted as possible ileitis and some signs of avitaminosis. The terminal ileum could not be visualized with a barium enema although several attempts were made. On November 21, 1945, the patient was transferred from the medical to the surgical service where he was prepared for exploration which was performed on December 3, 1945.

At operation a large constricting mass about 8 cm. in diameter was present in the ileum just proximal to the ileocecal valve. The colon was collapsed and the terminal ileum hypertrophied and dilated. Enlarged lymph nodes in the mesentery and in the region of the celiac axis were noted. The terminal ileum and ascending colon were resected, a Mikulicz type of operation as described by Lacey<sup>3</sup> being deemed advisable in view of the condition of the ileum resulting from chronic obstruction. Closure of the ileocolostomy was considerably delayed due to extensive excoriation of the skin and gross contamination. Closure was finally effected in the face of considerable residual excoriation and contamination.

The pathological report (by Dr. Joseph M. Lubitz) was as follows:

"Gross Description: A piece of bowel is removed which includes the terminal ileum and cecum. The ileum is dilated. The serosal covering is dull in color, deeply congested. The mucosal surface is similarly congested. At the terminal ileum, just proximal to the ileocecal valve there is a crater, measuring 7 x 4 cm. At the proximal portion there is an elevated,



FIG. 2. Photomicrograph, reticulum cell sarcoma. Tumor cells invade mucosa and muscularis.

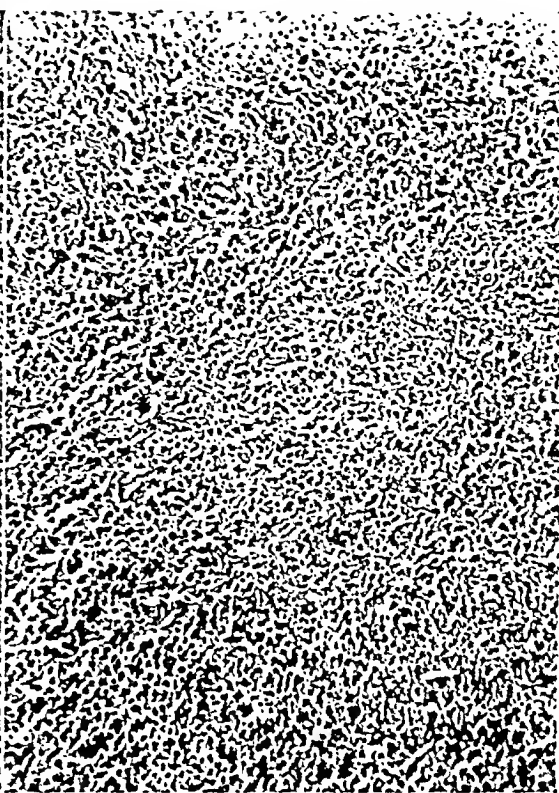


FIG. 3. Photomicrograph, submucosa, showing cellular detail of tumor.

firm margin surrounding it. In the central portion of this mass, there is a constriction which barely admits the point of a 5 mm. probe. In this portion the tissue is firm, gray in color and rubbery hard in consistency. This firmness extends to the wall and forms a node on the mesenteric attachment, measuring 5 x 3 cm. The base of this ulcer is corrugated and smooth. The ileocecal valve is patent. The cecum and ascending colon measure 15 cm. Here, too, the peritoneal surface is congested but is smoother. A mass from the mesentery is submitted, measuring 4 x 1 cm. On section numerous small nodes are found. One, however, is slightly enlarged, measuring 5 x 2 cm., which is firm and pinkish gray in color.

"Microscopic Description: The mucosa is denuded. The entire submucosa is thickened and infiltrated by a rather uniform type of cell. This extends up to the muscularis and invades it. The cell is large, pale, with prominent nucleolus and well defined nuclear membrane. The cytoplasm is indistinct and syncytial in nature. The shape of the cell is polyhedral or fusiform. Mitoses are frequent. Occasional giant tumor cells are present. There are in places attempts at alveolar structure but for the most part it is undifferentiated. The tumor

has invaded the muscularis. The serosa is edematous and covered with a deposit of fibrin and polymorphonuclear cells.

"The lymph nodes show a marked follicular hyperplasia of reticulum cells and a rare mitotic figure. However, by means of the ordinary stains and the reticulum stains it has been impossible to locate any tumor cells in several blocks of tissue.

"Diagnosis: Reticulum cell sarcoma; chronic lymphadenitis of mesenteric lymph nodes."

#### CONCLUSIONS

Except for extreme excoriation and infection which delayed closure of the ileocolostomy, recovery was uneventful. When last seen July 9, 1946, the patient was preparing to resume his occupation as a merchant seaman.

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# INFLAMMATION OF THE VERMIFORM APPENDIX BY METALLIC MERCURY

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THE method for rapid intestinal intubation with the Miller-Abbott tube described by Franklin I. Harris of San Francisco has been a real contribution to the technic of intestinal decompression.<sup>1</sup> This procedure is the one in which the terminal balloon is weighted with metallic mercury to facilitate its passage through the pyloric sphincter.

It has been stated that no fear need be held concerning the possible dangers to the patient if the balloon breaks as the mercury is not absorbed from the gastrointestinal tract.<sup>1,2,3</sup> Pharmacologic texts substantiate this view.

The differences in action of the various mercury compounds are due to variations in the solubility and dissociability of the several salts. Even the metal may be oxidized and absorbed when it is applied to large surfaces or injected into the blood in a state of fine division. Examples of toxicity from metallic mercury are cited following the inhalation of mercury vapor or the application of mercury ointment to the skin.

The author has observed an instance of irritation of the vermiform appendix by metallic mercury in a case of carcinoma of the rectum.

## CASE REPORT

A twenty-eight year old white male (H. L.) was admitted with an obstructing carcinoma of the rectosigmoid. A Miller-Abbott tube was introduced a few days before surgery and metallic mercury introduced into its terminal balloon. The balloon ruptured and allowed the liquid mercury to escape into the intestinal tract. The course of the mercury was followed by x-ray. Within twenty-four hours all of the mercury had migrated to the large bowel

except for a portion which had been entrapped in the appendix and, being radio-opaque, had produced a distinct shadow on the x-ray plate of an engorged appendix. (Fig. 1.) The appendix was removed at the time that colostomy was performed. The appendix was 9 cm. in length, distended, injected, and had lost its normal peritoneal sheen.

The pathological report states: "The organ is swollen, succulent and the serosa is engorged and edematous. Opened longitudinally, the lumen is found to be filled with fluid, clotted blood and small pieces of yellowish soft tissue. Small globules of metallic mercury are seen in the bloody contents and adjacent to the surface of the mucosa. The tip has a thickened wall and the lumen is filled with clotted blood and a few globules of mercury. The mercury globules are identified by amalgamation with gold foil. Microscopic: Six sections are taken at various levels. There is widespread hemorrhage in the depths of the mucosa with ulceration of large islands of the outer portion of the mucous membrane. The remaining mucosa is infiltrated with polymorphonuclear and eosinophilic leukocytes and plasma cells. The germinal centers of the lymph follicles show focal necrosis. The submucosa is thickened by a dense connective tissue. The muscularis is infiltrated with eosinophilic leukocytes. The serosa shows a tremendous engorgement of the blood vessels with early exudation of polymorphonuclear leukocytes. Many areas of hemorrhage are seen in the serosa. Diagnosis: Acute appendicitis. The inflammatory process is apparently due to the direct action of metallic mercury." (Figs. 2 and 3.)

No toxic physiologic abnormalities were discovered during study of the patient preoperatively after the accidental rupture of the balloon had occurred. Subsequently a resection of the rectosigmoid was undertaken by the author with uneventful recovery. The patient was discharged from the hospital in good general condition.



FIG. 1. Vermiform appendix filled with metallic mercury. Several globules are seen in ascending colon. (This picture is reversed; the appendix shows on the opposite side.)

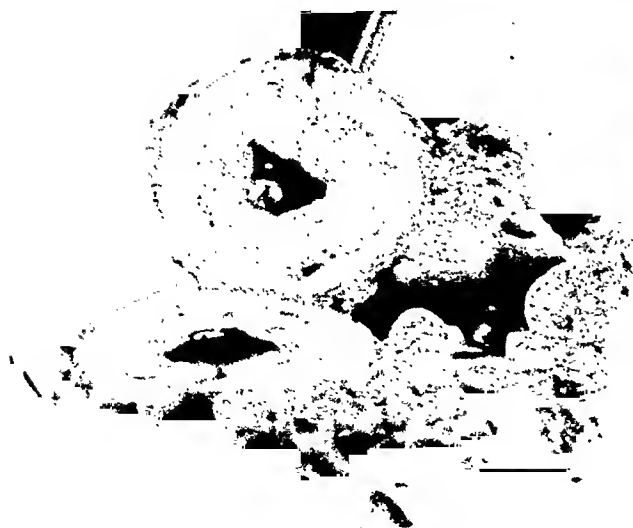


FIG. 2. Cross section of vermiform appendix; approximately  $\times 5$ . Note globules of metallic mercury, hemorrhagic detritus in lumen and edema of appendiceal wall and of meso-appendix.



FIG. 3. Cross section of vermiform appendix.

## SUMMARY AND CONCLUSIONS

A case is described of acute inflammation of the vermiform appendix due to the presence in its lumen of metallic mercury, accidentally introduced when the balloon of a Miller-Abbot tube, filled with mercury, ruptured.

The lumen of the appendix was distended by the mercury which alone could account for the ulceration and hemorrhage in the mucosa. Bacterial invasion quickly follows a break in the mucous membrane. A direct toxic action by the mercury is not likely in view of its insolubility.

There was no apparent mercury poison-

ing from free mercury in the intestinal tract. The mercury in this instance was trapped for a longer period of time than that reported in other cases.

In the new tube described by Dr. Harris, which embodies the same principle, there is less chance of the bag breaking.

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CONSTIPATION is so usual in the early stages of acute appendicitis that when diarrhoea accompanies it the true diagnosis is liable to be overlooked. If diarrhoea is accompanied by even slight, but constant, tenderness and some rigidity in the right iliac fossa, other things being equal, the appendix should be explored.

From "A Short Practice of Surgery" by Hamilton Bailey and R. J. McNeill Love (H. K. Lewis & Co. Ltd.).



# New Instruments

## SET OF BONE CHISELS, OSTEOTOMES AND GOUGES

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**D**URING the recent World War II, when it became difficult to obtain surgical instruments, I designed, from broken and discarded material or ordinary hardware carpenter tools, a set of chisels, osteotomes and gouges, which

permit proper grasping power and control of the cutting edges. When too short, they also obscure the view of the operative field.

All of the instruments are 10 inches (25.4 cm.) in length, which permits the

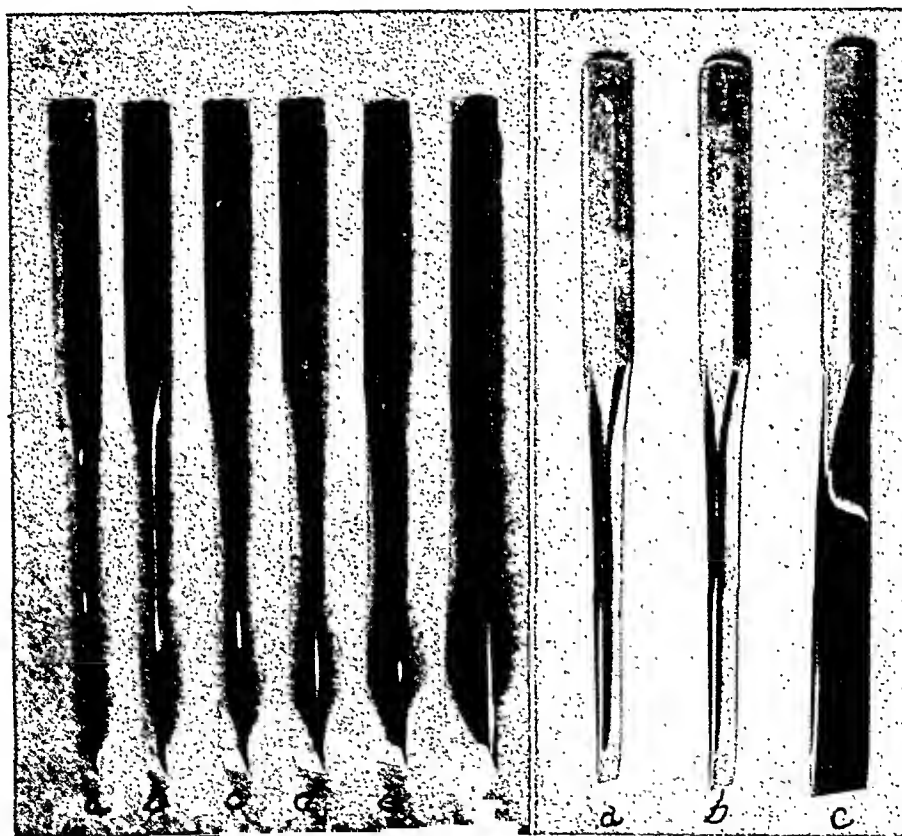


FIG. 1. Chisels: a,  $\frac{3}{8}$  inch (1.0 cm.) in width; b,  $\frac{1}{2}$  inch (1.3 cm.); c,  $\frac{5}{8}$  inch (1.6 cm.); d,  $\frac{3}{4}$  inch (1.9 cm.); e,  $\frac{7}{8}$  inch (2.2 cm.), and f,  $1\frac{1}{8}$  inch (2.9 cm.).

FIG. 2. Osteotomes: a,  $\frac{3}{8}$  inch (1.0 cm.) in width; b,  $\frac{1}{2}$  inch (1.3 cm.) and c, 1 inch (2.5 cm.).

have proved practical and are in daily service at the Mayo Clinic. I found that the usual chisels, osteotomes and gouges employed in bone surgery were deficient in size, especially length, the handles therefore being too small to

surgeon to reach the depths of wounds encountered in operations on the spinal column and thigh and not obscure vision of the operative field. There is also ample length of the shank, which permits sharpening of the instrument for years. All of

the handles are hexagonal and  $\frac{3}{4}$  inch (1.9 cm.) thick by  $4\frac{1}{2}$  inches (11.4 cm.) in length, which permits firm grasping power and control of the cutting edges. Handles are heavy so that when the instruments are dropped the cutting edges are protected. The instruments are made of stainless steel or carbon steel, which material is hard enough to withstand the stress and strain of constant usage without chipping or dulling, and has proved dependable and serviceable. There is no satisfaction in working with dull instruments, which sometimes are dangerous. I feel that the surgeon and nurse should take pride in the care of instruments and that a dull or broken cutting edge usually is the result of improper usage or careless handling.

There are six sizes of chisels with straight shanks as shown in Figure 1. These chisels have been found satisfactory for most bone surgery.

There are three osteotomes with straight shanks as shown in Figure 2. The  $\frac{3}{8}$  inch (1.0 cm.) osteotome is useful in removal of bone grafts or cutting a trough in the smaller bones. The  $\frac{1}{2}$  inch (1.3 cm.) osteotome is employed in performing osteotomy of the radius, ulna and smaller bones, and the 1 inch (2.5 cm.) one for osteotomy of the femur and humerus.

There are two gouges with curved shanks and cutting edges. This shape permits the surgeon to chisel cavities with greater ease than does the usual straight shank. The gouges are most useful in chiseling and removing regions of osteomyelitis and of tumor tissue and in roughening bone surfaces. I use the  $\frac{3}{8}$  inch (1.0 cm.) gouge to scrape the film

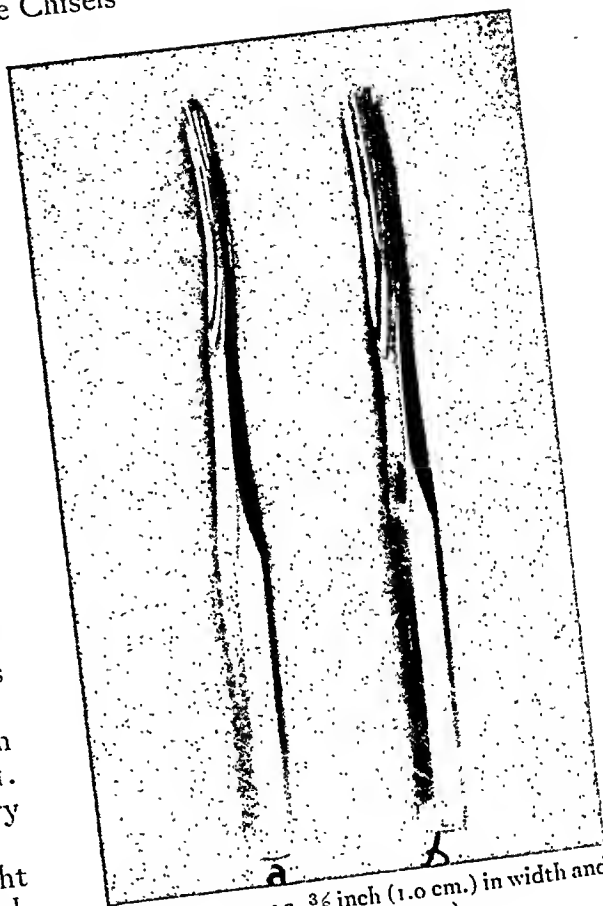


FIG. 3. Gouges: a,  $\frac{3}{8}$  inch (1.0 cm.) in width and b,  $\frac{5}{8}$  inch (1.6 cm.).

tissue from the sacrum and to raise fish scalelike areas on the sacrum in performing bone graft to the lumbar vertebrae and sacrum. New bone grows more rapidly from these chipped fish scalelike areas than from the smooth surface of the sacrum. This aids in obtaining a firm and rapid bony fusion between the bone graft and the sacrum.<sup>1</sup>

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## Editorial

### PRESIDENTIAL ADDRESS

RALPH G. CAROTHERS, M.D.

*Cincinnati, Ohio*

SOME years ago when I helped write the constitution of this Association I did not realize that someday I would be elected president and have to make a presidential address. Had I been able to see that far into the future I still do not believe I would have realized how difficult such a project could become. However, I will do the best I can for I believe that no matter how arduous a task, it is a small price to pay for the honor of having been elected your president.

Years have passed now since this Association was organized and this is only our seventh session; had it not been for the war it would have been our ninth. And we really had one other, namely, the organization meeting in San Francisco in 1938. Therefore, this should have been our tenth meeting. As a result of the passage of time some familiar faces have disappeared and many new ones have come in. I shall try to address most of my remarks to these new members so they may, in a way, catch up with the aims and traditions of this Association and know something about the origin.

It was a very cold rainy day in December, 1937, when a small group of us sat together at luncheon at the meeting of the Western Surgical Association in Indianapolis. Among those who are present were: Drs. Edgar L. Gilcreest, Eslie Asbury, William Cubbins, Arthur Metz and I. There may have been some others but I

do not remember now who they were, nor do I remember just how the subject of trauma came up. However, it was evident that we who were sitting together were very much interested in that subject and were not getting too great a kick out of some of the other papers which were being read at the meeting we were then attending. The net result of the matter was that suggestions were made for the formation of an association such as we have today. As a matter of fact, we talked about it so much that we decided to hold another meeting the following week in Birmingham, Alabama, where the Southern Surgical Association was convening. At that meeting several more were added to our little gang, as it were, and we talked loud and long of the possibilities of forming the association. The net result was that a temporary committee was organized of which Dr. Gilcreest was made chairman and I the secretary.

Others on that committee were: Dr. William L. Estes, Jr., of Bethlehem, Pennsylvania; Dr. Charles C. Green of Houston, Texas; Dr. R. Arnold Griswold and Dr. Frank P. Stricker of Louisville, Kentucky; Dr. Kellogg Speed, Dr. Albert H. Montgomery and Dr. Arthur R. Metz of Chicago; Dr. Ross A. Woolsey of St. Louis and Dr. George W. Swift of Seattle.

This was followed as months went on by many trips on my part and also on the part of

Dr. Gilreest to various parts of the country to interview and discuss the matter with many men. In addition to this a great many letters were written. As a result of these many interviews, many of which were held all the way from New York to Los Angeles and up into Canada, a good list of men who might be interested in such an association was developed.

A letter was drafted after consultation with various members of the committee, the letter was signed by Dr. Gilreest and sent out to the men who were on our list. These men were invited to meet in San Francisco on June 14, 1938, which was Tuesday of the week of the meeting of the American Medical Association.

A goodly number appeared at that meeting and the association was formally organized and set into motion. Dr. Kellogg Speed was made the first president, Dr. Edgar L. Gilreest the president-elect, Dr. Frazer B. Gurd, vice president, Dr. Arthur R. Metz, treasurer, and Dr. R. Arnold Griswold, historian, and I secretary. The council which was also elected at the same time consisted of: Drs. Casper R. Hegner, Charles C. Green, Hubley Owens; Gordon M. Morrison and Grover C. Penberthy.

Now it may be interesting to the younger members here today to know why we were motivated to form such an organization. The reason was a simple one. We were interested in the surgery of trauma and most other surgeons were not. All of us were members of one or more of the older, well organized, surgical organizations and we had attended meetings regularly and enjoyed them very much. But we heard very little on the subject of trauma. In fact, this has been true for sometime.

Some years ago trauma played a large part in the work of the surgeons of any one large city hospital. In fact, there was in those days, just surgery, general surgery it was called, and it included practically everything in the entire field. There are men living today who have done operations from the eye to the toes. Sir Berkley Moynihan treated fractures, or at least his house surgeon did; Hugh Owen Thomas wrote on peritonitis and there was the Lane plate and the Lane kink. The scope of surgery had not been developed to the extent that it is today, and trauma occupied a very large part of what there was. However, at about the turn of the century before automobiles had become common and before the machine age of today, specialism began to appear in surgery. This

was brought about partly by the improvement in anesthesia, operating technic and the development of new instruments. The result was that more and more surgeons became interested in elective surgery and more and more operations within the cavities of the body were performed. These operations were more exciting; they paid better; they could be done at a more convenient time. There was more drama in this newer surgery. After all, cutting off a man's leg was not much different from cutting off a horse's tail, but to go into the abdominal cavity and remove some part of the stomach and put it all back together—well that was as thrilling as a Blalock operation is now. The development of the specialities and the multiplication of instruments became so great that after a while it seemed impossible or at least improbable that anyone would master the technic of more than one or two specialities.

Now the development of the surgical specialities was, in many respects, a good thing. The field was broadened to a tremendous degree. New surgical approaches to many old diseases which had proved incurable in the past were developed. A great deal of good came out of the movement. But there was one rather unfortunate phase of this trend, and that was as each specialty developed the proponents seemed to drop the trauma part of whatever organ or area they proposed to treat. One could hear the remark made on every hand, "Oh, I don't treat fractures, I turn them over"; "I don't handle those things, I don't want to go into court"; "I don't want to get called out at night"; "the best way to treat a fracture is to send it to your worst enemy." In addition to this there arose another phase of the matter, namely, the Industrial Commissions and insurance companies became interested in these cases and this brought a little money into the picture. It was only a little money and entailed a great deal of additional paper work. In many instances an inferior type of practitioner began to grab the injured workmen, so that in some areas it became rather disgraceful to handle such cases. Treating cases of trauma was rather like practicing criminal law.

The net result of all this was that when World War I broke out the surgeons of the various countries were to some extent stymied with war wounds. They had not seen the horrible automobile accidents which we see

everyday, for most of these men had spent all their time doing elective operations and except for acute appendicitis and empyemas they worked largely with clean cases. There were plenty of men who could perform brilliant surgical operations up at the front at the casualty clearing stations but very few seemed to know how to handle these patients after they got back to the base. The result was that more and more hospitals in England and in France were getting more and more filled with people who were seriously injured and getting not very good care. Dr. Gilcreest knows this first hand from his experience in the Balkan area; I saw it when attached to the British Army and a good many others here saw it, too.

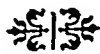
But there were men like Norman Kirk and Paul Hawley and others who stayed in the service and saw to it that when World War II broke out our Medical Corps had nothing to be ashamed of. And there were some others of us who back in civil life attempted to make surgery of trauma, which was increasing rapidly, interesting and decent.

Soon after World War I, Dr. John A. Caldwell formed a fracture service in the Cincinnati General Hospital, and Dr. Eslie Asbury and I formed one in the Good Samaritan Hospital in Cincinnati. Out of these two services many young house surgeons were trained in the practice of the surgery of trauma. The movement became so popular that now every hospital in and about our part of the country and a great many others, too, have such services.

So here we are today a group of surgeons gathered together for the purpose of studying the problems connected with trauma to the human body. I like to think of this as the

fundamental of all surgery. After all, surgery began with the incision and drainage of pus, the amputation of the hopelessly diseased parts and the repair of injury. Many things have happened to eliminate pus. We just do not have as much of it as we did at one time. To go back a little, when I was house surgeon in 1919, I saw appendectomies at an average rate of ten a day and I cannot recall one clean case. Today one sees the appendix removed cleanly far more often than otherwise. Not so very many years ago radical mastoid operations were very common. There are many men today who have never seen such an operation. Sometimes we do not even operate for osteomyelitis. What has happened to infections may happen to hopelessly diseased parts in another way. Someday somebody will find something to do about cancer and it will probably not be a surgical operation. But there is left the repair of injury and that will go on as long as man goes on. An Association like this is settled for a long existence because it deals with the very fundamentals of surgery.

Now one more word which I wish to direct primarily to our new members. Come to meetings; get acquainted. Those of us who have been coming to this Association have got out of it a great deal more than just surgical knowledge. We have formed friendships and associations that will go on for life and these are some of the most valuable possessions one can acquire. You new Fellows would not have been selected to sit here with us if we did not expect that you would become one of us in every way. So as I said before, come to the meetings, come and read papers, come and carry on the traditions of The American Association for the Surgery of Trauma.



# Original Articles

## FURTHER STUDIES IN SKULL FRACTURES AND BRAIN INJURIES

HARRY E. MOCK, M.D.

*Chicago, Illinois*

THE purpose of this paper is to sum up the experiences of one who has ridden a surgical hobby for twenty-five years. For those who may be critical of a general surgeon's interest in this highly specialized trauma, it should be pointed out that this study began before the advent of neurosurgeons in Chicago.

During these twenty-five years this author has: (1) Studied almost all of the articles appearing in the literature under various titles of "Skull Fractures," "Brain Injuries," "Head Injuries," "Cranio-cerebral" or "Cerebrocranial Injuries" and special subjects pertaining to these; (2) developed two survey sheets which have been used by himself, his associates and about twenty-five very altruistic and cooperative surgeons throughout the country in surveying the hospital records of consecutive patients with proved and practically proved skull fractures for five-year periods in twenty-six hospitals (in a few instances head injuries without fractures have been similarly surveyed) and (3) personally treated over 400 patients with proved and practically proved skull fractures and assisted in the treatment of 163 such patients seen in consultation.

In the same period he has treated 695 patients with head injuries without proof of fracture, patients who were unconscious or had some form of disturbed consciousness sufficiently serious to warrant at least six days of hospital observation and treatment. Another one-hundred consultations occurred for those patients with head injuries.

The keynote of this paper is what influences brain injury mortality rates and how may the same be reduced. The deductions herein set forth are based upon the experiences of other authors who have reported on consecutive cases with data concerning treatment and mortality rates, the studies of the manage-

ment of consecutive cases in these twenty-six hospitals and their mortality rates as well as upon the author's personal experiences. (Table 1.)

### WHO MUST TREAT BRAIN INJURIES

Craniocerebral injuries occur wherever automobiles are driven, trains are run, airplanes are

TABLE 1

#### CONSECUTIVE SERIES CRANIOCEREBRAL INJURIES

A. Studied from literature 1900-1946.....	15,426
B. Studied from surveyed hospital records	
1. 1928-1935.....	3,156
2. 1935-1940.....	3,106
3. 8 small hospitals 1939-1945.....	282
C. Personally treated and seen in consultation:	
1. Skull fractures.....	584
2. Head injuries without fractures.....	695
Total.....	23,249

flown, power machines or horses are used or homes with stairways, bathtubs or waxed floors are built. The faster the wheels of industry turn and the greater the farm production becomes the more the number of brain injuries increase. Games and the pastimes of the young and old, kicks from domestic animals and conflicts between individuals add to the incidence. The victims of this trauma frequent our smallest as well as our largest hospitals. In fact, there are many small but well equipped hospitals located near extremely busy through highways or near industrial centers where the number of craniocerebral injuries treated far exceeds the number in certain of our well established neurosurgical centers. When we consider that the above potential etiologic factors are scattered all over the land it is evident that every hamlet, village and city will have their quota of craniocerebral injuries.

It is noteworthy that in approximately 6,500 cases collected from twenty-six hospitals, 34.6

per cent were treated by or had neurosurgeons available, while in 65.4 per cent there were no neurosurgeons handy for the management of the patients. This further demonstrates that brain injuries are largely the responsibility of the general surgeon.

Moreover, the majority of deaths from skull fractures and brain injuries occur in the first twenty four hours, depending upon the efficacy of the management. In the author's series of cases, 64 per cent of the total number of fatal cases died within the first twenty four hours, while 60 per cent of these first day deaths occurred in the first six hours following the injury. In the consecutive cases surveyed from twenty-six hospitals 47 to 60 per cent of their total deaths occurred in the first twenty-four hour period. Thus it is evident that the type of management rendered during the first twenty-four hours, and especially during the first six hours, spells life or death for many of these victims.

Given the wide distribution and the high preponderance of deaths in the first twenty-four hours it is axiomatic that:

- (1) *A large proportion of brain injuries must be treated in hospitals far removed from the centers where neurosurgeons work.*
- (2) *The full responsibility for reducing the mortality rate in the majority of instances rests upon the shoulders of the general physicians and surgeons who first see these patients.*

In the subsequent days certain intracranial conditions may develop which make the presence and aid of a specialist in brain injuries mandatory. It is here that the neurosurgeon enters the field. Constantly remember that during the acute stage *the specialist must go to the brain injury not the brain injury to the specialist.*

#### WHY SKULL FRACTURES?

Several years ago a neurosurgeon wrote the author as follows: "This continued talk about skull fractures is extremely irritating to a neurosurgeon who realizes that the brain is the important structure and not the skull."

We still contend that proved or practically proved (basal fractures altogether) skull fractures furnish the best common denominator for evaluating the comparative seriousness of any consecutive series of brain injuries. We all

agree that it is not the skull fracture that is material, with the exception of depressed and compound fractures and certain linear fractures crossing branches of the middle meningeal artery or dural sinuses, but rather the amount of brain injury that determines life or death for the patient. No thoughtful surgeon absolutely ignores the skull fracture *per se*.

However, in reviewing many published articles on the subject of head injuries one finds:

1. Certain authors include all head injuries with a *history or evidence of unconsciousness* in their consecutive series of cases used to determine the mortality rate. Many include, while others eliminate, those head injuries which remain under observation in the hospital only twenty-four to forty-eight hours. Mortality rates published from such series vary from 4.5 to 10 per cent.
2. Certain authors include all head injuries which showed blood in the spinal fluid or had proved skull fractures. Their mortality rates vary from 17 to 21 per cent up to as high as 33 per cent. This classification involves practically a routine lumbar puncture, performed in the majority of cases as a diagnostic procedure but really for statistical purposes.
3. The author, reporting on proved or practically proved skull fractures in 421 cases treated personally, has a mortality rate of 16.8 per cent. If he adds those very serious head injuries, without proved skull fractures but with blood in the spinal fluid, his mortality rate jumps to 20 per cent, comparable to that shown by Wright, Fay and Rolette and Weiner, authors who included truly serious head injuries with their skull fractures.
4. However, if he adds the total number of head injuries treated by him since 1928 to his total number of skull fractures, the author has a series of 1,119 *head injury cases*. These 698 patients with head injuries without proof of skull fractures include only patients who showed unconsciousness and who were retained in the hospital for observation and treatment for at least six days or longer. The mortality rate in these head injury patients was 9 per cent, while the total mortality rate for the 1,119 skull



fracture-brain injury cases was 12 per cent.

Since, in the author's large series of collected cases secured from hospital records he had no opportunity of studying their consecutive run of head injuries without skull fractures, he,

TABLE II

SKULL FRACTURE GROUPS ACCORDING TO TREATMENT  
MORTALITY RATES IN EACH GROUP

Group	Treatment	Cases in Group, Per Cent	Deaths, Per Cent
I	Rest and observation only	5.5	0
II*	Simple medication, controlled dehydration	49.5	7.0
III†	Spinal drainage	36.0	29.0
IV	Operations	9.0	26.0
	Totals	421	16.8

\* Includes 21 early deaths occurring before any treatment administered.

† 92% bloody spinal fluid.

therefore, uses for comparison his and their series of proved or practically proved skull fractures. This gives the common measuring rod for comparison of methods of management and the varying mortality rates between all the hospitals studied. With few exceptions the presence of the skull fracture is no indication of the management needed.

#### HOW SERIOUS ARE SKULL FRACTURES?

Many serious head injuries with brain trauma do cause deaths even when a skull fracture is not present, but in every consecutive series of patients with truly serious head injuries without fractures studied from the literature, from the collected cases and from the author's personal series the mortality rates for head injuries varied from 5 to 15 per cent lower than for skull fractures.

In 1931, the author reported on his first consecutive series of one-hundred patients with proved and practically proved skull fractures. These were classified into four groups according to the treatment administered. The signs and symptoms which seemed to depict the underlying pathologic condition in each group were then analyzed to ascertain the *why* for the treatment given. He has continued this classification. It has furnished him increasing knowl-

edge concerning those signs and symptoms which demand a given treatment. (Table II.)

From his 698 patients with serious head injuries without fractures the last 150 were analyzed and grouped as to treatment. (Table III.)

TABLE III

HEAD INJURIES—GROUPS ACCORDING TO TREATMENT  
MORTALITY RATES EACH GROUP

Group	Treatment	Cases in Group, Per Cent	Deaths, Per Cent
I	Rest and observation only	22.0	0
II	Simple medication, controlled dehydration	63.3	5.2
III*	Spinal drainage	14.0	27.2
IV	Operations	0	0
	Totals	150	7.3

\* 45% showed blood in spinal fluid.

Tables II and III give another excellent example of the comparative seriousness of proved skull fractures and of head injuries without fractures. The more one dilutes his skull fracture series with head injury cases without fractures the lower his mortality rates decline.

Grading each skull fracture case record from each of the nineteen hospitals surveyed from 1935 to 1940, according to observation, interpretation of signs, symptoms and treatment administered, Mock and Mock, Jr. were able to classify these hospitals into good, average and poor management groups. Table IV shows the mortality rate in each hospital group.

#### HOW SERIOUS ARE VARIOUS TYPES OF FRACTURES

Three thousand one hundred ninety-four of the collected skull fracture cases from nineteen hospitals, including 300 of the author's, were studied to ascertain the location of the fracture. These were divided among the nineteen hospitals classified according to good, average and poor treatment. The death rate according to location of the fracture is shown (Table IV) it also gives the relative seriousness of vault, base and combined vault-base fractures.

It is evident that vault fractures give the



lowest mortality rates. Mortality rates as low as 4 to 9 per cent for simple vault fractures have been reported in the literature. The good (A to D) and average (E to I) hospital groups and the author's series confirm these assertions. In the poor management group, even though 50

lying brain and not the fracture is the cause of death. Since we cannot lift off the vault of the cranium and directly visualize the type and character of this cerebral damage *in vivo*, it is impossible to make a comparable classification of brain pathology similar to the cranial pathol-

TABLE IV  
LOCATION OF FRACTURES AND DEATH RATE

Hospital, No. Cases	Total Death Rate, Per Cent	Vault, Per Cent	Death Rate, Per Cent	Base, Per Cent	Death Rate, Per Cent	Com- bined, Per Cent	Death Rate, Per Cent
Author's 300 cases.....	16.6	34.0	5.8	30.0	20.0	36.0	24.0
Hospitals A to D, 324 cases.....	19.7	50.9	9.0	24.7	38.0	24.7	20.0
Hospitals E to I, 1,822 cases.....	30.2	45.0	10.8	39.0	51.8	16.0	17.2
Hospitals J to S, 748 cases.....	33.2	50.0	22.7	25.0	62.5	23.6	25.4
Totals—3,194 cases.....	914 28%	1,384 43%	187 13.5%	986 30%	492 50%	666 20%	137 20.5%

In 7% location not stated.

per cent of their fractures were vault fractures, the mortality rate more than doubles that shown in any of the other groups. It was in this poor management group that the “do nothing” treatment and “watchful neglect” were chiefly practiced. The fact that it is a vault fracture does not limit active treatment.

ogy. Here we must depend upon the signs and symptoms of each individual patient to even approach a true diagnosis of the cerebral pathology.

The time-honored classification of concussion, contusion, laceration and hemorrhage still is sound. Unquestionably, there are thousands

TABLE V  
COMPLICATED VAULT FRACTURES

Source	Total Cases	Death Rate	Depressed		Compound		Compound Depressed	
			Cases	Deaths, Per Cent	Cases	Deaths, Per Cent	Cases	Deaths, Per Cent
Author's.....	300	16.6	33(11%)	18	9(3%)	33.3	6(2%)	50.0
Hospitals A to D.....	324	19.7	25	20.0	2	100.0	4	50.0
Hospitals E to I.....	1,822	29.0	109	21.0	60	53.3	15	26.6
Hospitals J to S.....	748	33.2	85	31.7	55	38.2	13	53.8
8 Small hospitals.....	282	26.9	38	31.5	11	27.2	12	58.3
Totals.....	3,176	29.5	8%	26.0	4%	45.3	1.4%	45.4

From 3,176 hospital records surveyed the complicated vault fractures were studied to ascertain the relative seriousness of depressed, compound and compound depressed fractures. (Table v.)

With all the above described fractures, simple and complicated, the damage to the under-

of cases of simple concussion, especially in children and young adults, occurring daily which never reach the hospitals and, therefore, are seldom included in statistical studies. Unquestionably, a variable degree of concussion, whether it is due to localized cellular changes, minute petechial hemorrhages or a commotio

cerebri, accompanies every contusion, laceration and hemorrhage case. Furthermore, every laceration and hemorrhage is accompanied by a certain amount of contusion to the brain and every hemorrhage must have some type of laceration. The classification of hemorrhage in regard to extradural, subdural, subarachnoid or cerebral can often be made by signs, symptoms or character of the spinal fluid. However, in many cases the hemorrhage is accompanied with such extensive contusion and lacerations that the diagnosis is made at the autopsy table. Finally, all of the above except concussion unquestionably are accompanied by variable degrees of localized or generalized edema. Even in concussion microscopic studies might reveal microscopic amounts of interstitial fluid.

From the standpoint of influence on the mortality rate, hemorrhages and lacerations rank first and contusions second. It is still a moot question whether simple concussion results in death. In our experience the cerebral laceration into the ventricle, giving almost pure blood in the spinal fluid, carries the highest mortality rate. The condition is suspected in life by doing the above mentioned spinal puncture. In several such patients treated by the author only one recovered. The tear into the ventricle was proved in six cases at autopsy.

#### MORTALITY RATE IN RELATION TO ETIOLOGY

The ratio of males to females with skull fractures in all the series studied showed approximately the same relationship, viz., 83 per cent males and 17 per cent females, with the death rate approximately 5 per cent higher among the males, suggesting the greater hazard of the causal factors.

The number of cases in each decade and the mortality rate for the given decade has been worked out in 3,184 cases. The relationship between the author's series and the good management series, as regards age decades and mortality rates, remains fairly uniform. The increasing mortality rates as we progress from average to poor management is quite dramatic.

Children survive skull fractures and brain injuries far better than adults. As a rule the treatment of these children need not be as drastic as it is in the older generations. In the earlier literature of this century, a hang-over from the teachings in the 1890's, one gains the impression that most surgeons believed "leave the skull fracture child alone and he will get well."

As a result many serious brain injuries have received "watchful neglect." This tendency is reflected in the higher mortality rates in the average poor management and small hospital groups. While not occurring as often, certain children need spinal drainage the same as certain adults.

TABLE VI  
AGE PERIOD

Age Period	Good to Above-Average Treatment		Average to Poor Treatment	
	From % to % Cases	From % to % Deaths	From % to % Cases	From % to % Deaths
0-10 yr...	5 to 17	5 to 7	13 to 20	15 to 20
10-50 yr...	65 to 70	10 to 20	57 to 75	15 to 35
50-70 yr. or over....	13 to 20	22 to 48	4 to 30	36 to 75

Fox and Blankstein,<sup>1</sup> in 1941, reported on 285 proved skull fracture cases in children treated in the Milwaukee Children's Hospital between the years 1922 and 1939. There were fifteen deaths in this series of 285 cases, a mortality rate of 5.26 per cent. They believe that the majority of children show marked shock from their craniocerebral injuries and require the most painstaking management during the early hours following injury. Forty-six and six-tenths per cent of their fifteen deaths occurred in the first twenty-four hours. Their results are comparable to the experiences of the author and the surgeons who treated the children in the good management hospitals. These facts set a goal for the poorer management groups when their children mortality rates mount to 20 per cent, the age decade most kindly responsive to treatment if given a chance.

A more detailed analysis of the age decades reveals that as treatment descends from a good to above average management, downward to an average to poor management, a marked increase in the mortality rates for each age period may be expected. (Table vi).

The cause of these brain injuries was studied in some 3,500 cases. The automobile caused from 36 to 50 per cent, the higher percentages coming from the metropolitan areas. Falls caused from 20 to 38 per cent; blows 12 to 21 per cent; trains and streetcars 2 to 8 per cent,

with numerous other causes accounting for a fraction of 1 per cent of the cases. The mortality rate was highest in streetcar injuries, then trains and finally automobiles.

#### MORTALITY RATES IN REGARDS TO SIGNS AND SYMPTOMS

Time will not permit a detailed analysis of the innumerable signs and symptoms and their varied combinations which follow in the wake of a traumatized brain. There are certain outstanding facts, however, which should be mentioned because of their marked influence on the mortality rate. It is from these facts, gathered from close observation of the patient, that prognosis concerning the outcome is made. A prognosis based upon the percentage of chance of recovery gives some comfort to the anxious relatives even though it is the proverbial "grasping at a straw."

Disturbed consciousness is, of course, the predominating symptom of brain injury. It was present in some form in 85 per cent of 2,685 collected cases when the signs and symptoms were recorded fairly carefully. This group had 844 deaths, or a mortality rate of 31 per cent.

Unconsciousness varies from a mild semiconscious condition to a deep loss of consciousness. It differs from coma in that there is an effort to respond to some spoken command, or in the absence of this, there still remains some definite response to pain stimuli, pinching of the arm or thigh causing the unconscious patient to move the part. In a coma there is neither sensory nor motor response. The disturbed consciousness may be modified or qualified by such descriptive terms as dazed, drowsy, stuporous or confused, noisy, delirious or a definite "lucid period." In surveying these hospital charts an attempt was made to tally the state of disturbed consciousness under the descriptive term used most frequently by the surgeon, or in some instances by the nurses, who recorded the same terms on the hospital record. This does not give an exact picture of each case but in a large series of cases it gives a fairly composite picture.

Unconsciousness, as described above was recorded in 30 per cent of this series of 2,685 cases and carried a mortality rate of 34.4 per cent; coma was recorded in 27 per cent of the cases and had a mortality rate of 65 per cent; *dazed*, *drowsy* and *stuporous* (seriousness increasing in that order) were recorded in 18 per cent of the

cases and had a mortality rate of 22 per cent; *confused*, *noisy* and *delirious* were recorded in 7 per cent and the mortality rate was 23 per cent while *lucid interval* was described in 3 per cent of the cases and had a mortality rate of 25.5 per cent. This may well depict the extradural and sometimes the subdural hemorrhages which Munro and others claim are overlooked too frequently. Milder states of disturbed consciousness made up the other 15 per cent.

When the above states of disturbed consciousness are accompanied with focal signs, such as twitchings, paresis in an extremity, hemiplegia, convulsions, the deep and superficial reflexes sluggish, completely absent or frequently changing in character and especially if a Babinski sign is present, then the percentage of chances against the patient's recovery increases. His stock fluctuates, gradually goes up or quickly slumps, according to the intensity and persistence of these signs and symptoms. Of all these signs, persistent focal phenomena and complete absence of reflexes are far more serious tokens than are convulsions and frequently changing reflexes. Remember, that fixed pupils, constricted, dilated or irregular in size belong in the category of absent reflexes and offer grave indications of seriousness. The retention of urine or bladder and rectal incontinence belong in the same category. Other signs which facilitate one's estimate of the gravity of the situation are:

*Slowed pulse and slow respiration* which were two of the constant signs frequently mentioned by the old writers and which they considered bad prognostic signs if they persisted. Pulse rates of 40 to 60 and respirations of from 4 to 12 were recorded in many of the first twenty-four hour deaths. Unless pulse and respiration are recorded frequently, these signs are usually overlooked. This may account for the fact that some authors belittle their existence. When the slowed pulse and respiration are followed by a rapid and mounting pulse and respiration rate, one or both, or when the pulse becomes irregular and Cheyne-Stokes respirations develop, their prognostic implications are deeply enhanced; stabilization near normal is indicative of improvement. A persistently low diastolic pressure, 20 to 40 and even 60, is a grave indication. When accompanied with a high or a mounting systolic pressure, thus giving a mounting pulse pressure, the situation becomes more grave. To the author the blood pressure

is a far more sensitive indicator of medullary compression than are the pulse and respiration rates. Fifteen years ago, in a symposium on brain injuries, several speakers placed very little value on blood pressure information. In the recent literature practically all of the authors emphasized blood pressure information, especially the low diastolic and the increasing pulse pressure. This fact seems to confirm the author's views which he expressed first in 1931.

Edema of the lungs frequently accompanies these blood pressure and respiratory signs of gravity. In some cases it may be due to direct medullary compression but coming so early after injury as it often does it is more probably on a reflex vagus basis. Whatever its cause it is exceedingly dangerous to the life of the individual. Many a brain injury patient has literally drowned to death. Many have been saved by prompt postural drainage or aspiration.

Temperatures of 100 to 102°F. are present in a great majority of patients with true brain injury. Subnormal temperatures as low as 96°, and in one case 95°F., were recorded in many of the first few-hour deaths. The great majority of fatalities with early temperature readings over 103°F. die in the first twelve hours, thus indicating a very early disturbance of the heat regulating mechanism. In a lesser number of cases these high temperature readings may take two or more days to reach extreme heights. In children the temperature may sometimes go to 106°F. with recovery following. In only two instances has the author seen such temperatures in adults who recovered. In adults with damage to the heat mechanism any temperature reading of 103°F. or over warrants a grave prognosis, increasing in gravity with the rising temperature. In several patients the author witnessed temperatures of 108° and in two consultation cases it was recorded on rectal thermometers as high as 110°F. In one series of 1,347 cases, 614 gave sufficiently careful temperature records to warrant the following detailed analysis. (Table VII.)

Complications, that is, associated injuries and complicating diseases must be taken into account in evaluating mortality potentialities. In a previous publication the author showed the effect of associated injuries upon skull fracture brain injury mortality rates. (2) Suffice to say that the death rate increased from 4 to 11 per cent in the good to above average manage-

ment cases and from 12 to 18 per cent in the poorly managed group when associated injuries were present.

A careful review of all these records indicates failure to observe the rules for treatment of shock, definitely enhanced by the associated

TABLE VII  
RECORDED TEMPERATURES IN 614 CASES

	Temperature	No. Cases	Deaths, Per Cent
During 1st 4 hr.	103-104	28	85.0
	104-105	12	83.0
	105-106	3	100.0
	106-108	2	100.0
During 4 to 12 hr.	103-104	29	86.0
	104-105	11	81.8
	105-106	12	100.0
	106-108	14	100.0
During 12 to 24 hr.	103-104	0	0.0
	104-105	0	0.0
	105-106	1	0.0
	106-108	4	75.0
During 24 to 48 hr.	103-104	6	66.6
	104-105	5	60.0
	105-106	9	88.8
	106-108	3	100.0
	108-109	1	100.0
During 2 to 4 da.	103-104	8	37.5
	104-105	3	66.6
	105-106	3	66.6
	106-109	4	100.0
Over 4 da.	103-104	11	36.0
	104-105	6	66.6
	105-106	8	25.0
	106-108	8	100.0
	109-110	1	100.0

Temperatures ranged from 100 to 103 degrees in 422 remaining cases with an average mortality rate of:

1st 4 hr.	44.0%
4 to 12 hr.	40.0%
12 to 24 hr.	13.5%
24 to 48 hr.	21.0%
2 days or more.	25.0%

injuries, scalp wounds sutured early, too many fractures immediately reduced, failure to use oxygen, especially in the presence of fractured ribs, and failure to recognize early and boldly attack the ruptured viscus. One of the deaths in the author's series occurred while the resident was suturing a scalp wound; another one might well be ascribed to too early and too active

treatment of the compound fracture; another one was probably due to overlooking the ruptured spleen, although five other patients with ruptured spleens and one with a ruptured liver were recognized, operated upon at once and all but one saved. Several patients with skull fractures complicated by fractured ribs died in the earlier years of the author's experience who today conceivably might be saved by the use of oxygen, postural drainage and aspiration of the accompanying pulmonary edema.

Meningitis is the bingaboo of skull fractures, especially fractures through the paranasal sinuses. In fact, operations for repair of the dura in the presence of cerebral spinal fluid leakage have been strongly advocated to prevent meningitis, even though the operation itself carries a high mortality rate. The author has a meningitis rate of occurrence of 1.5 per cent in his personal cases and 3 per cent when his consultations are included. Voris has reported on a series of cases showing the meningitis rate around 1 per cent. In the collected series of cases from the twenty-six hospitals the meningitis rate varied from .2 to 2.5 per cent. Meningitis should be reduced in these days of the sulfonamides, penicillin and streptomycin. However, future authors in reporting their results with these drugs in brain injuries, should bear in mind that the meningitis rate following cerebral trauma under old management was always exceedingly low.

Pneumonitis in its various forms is the most dangerous complication recorded in skull fractures. Here the new drug therapy, and especially the increasing use of oxygen and the early and more frequent postural changes in the patient, will undoubtedly reduce the incidence of this grave complication.

#### MORTALITY RATE INFLUENCED BY MANAGEMENT

There are many general principles of management of skull fractures and brain injuries concerning which we are all more or less agreed. There are certain special rules of procedure governing the treatment of these injuries concerning which there is still entirely too much controversy. The controversies have influenced many a surgeon, seeing only the occasional brain injury case, to use a "do nothing" treatment, a "do too much" treatment or a form of management that is summed up by a slogan becoming quite popular today, "watchful neglect." In other words, viewing brain injuries

as a nationwide problem these controversies have increased the mortality rate far more than we realize. One cannot talk to numerous county medical societies, hospital staff meetings and other small groups without having these impressions driven home. One cannot see many patients in consultation and hear the attending surgeon explain why he did or did not do this or that (quoting various authors) without realizing that too many patients were jeopardized because of controversies among those who should know the correct answers.

In a previous paper by Mock and Mock, Jr. in 1942,<sup>3</sup> a detailed study of the signs and symptoms present in each of the four treatment groups was made. The author has brought his group classification up to date for his entire 421 cases and added this to the chart previously published showing the groupings for the good, average and poor management in 3,106 cases from nineteen hospitals. (Table VIII.)

In a review of fifty-nine articles published since 1939, concerning all types of cranio cerebral injuries, thirty-four dealt with general management, twenty with operative treatment and the remainder with related problems. Nine of the papers dealing with operations also referred to spinal drainage and/or dehydration. Thus in a total of forty-three articles the authors favored carefully controlled dehydration in thirty-four, were opposed to it in two and did not mention it in seven. In these forty-three articles spinal drainage was strongly favored by thirty-six of the authors. Six used it but indicated a lukewarm attitude toward the procedure. In only one of the articles was spinal drainage completely condemned. This condemnation came from Cutler and Whitfield<sup>4</sup> who reported on a series of patients with 396 head injuries with a gross mortality rate of 11.8 per cent. They divide their cases into mild, moderate and severe groups. "44 per cent were mildly injured, and were unconscious less than 15 minutes . . . mortality rate 1.5%." Using their percentages and combining only their moderate and severe groups (60 per cent of the total) one finds a mortality rate of 19 per cent. They state that spinal drainage is "only mentioned to decry it." They further state it was used in only 3 per cent of their patients and has "now been abandoned because of one death ascribed to the procedure." This would indicate a very limited experience with spinal drainage. Comparing their mortality rate of

19 per cent with the death rates (17 to 21 per cent in proved skull fractures) in the four good treatment hospitals where spinal drainage was performed in 50 per cent of their cases, one is forced to conjecture concerning the soundness of their condemnation. Remember further that

rectum, through a Levine tube or by mouth. The great majority of these authors are strong advocates of the early use of spinal drainage after shock has been overcome. The author is still confident that 50 per cent glucose used only when signs and symptoms indicate danger

TABLE VIII  
COMPARATIVE RESULTS OF GOOD, AVERAGE AND POOR MANAGEMENT

Hospital	No. of Cases	Group 1. Rest only	Group 2. Dehydration	Group 3. Spinal Puncture	Group 4. Operation	Gross Death Rate
Author.....	421	5.5%	49.5%	36.0%	9.0%	16.8%
Good, A to D...	323	2% to 18% Average 8.0%	11% to 62% Average 36.0%	18% to 60% Average 50.0%	4% to 7% Average 5.8%	17.0% to 21.0%
Average E to I...	2,033	5% to 18% Average 11%	42% to 76% Average 50%	14% to 39% Average 28.3%	4% to 25% Average 10%	23.0% to 29.0%
Poor, J to S.....	750	5% to 32% Average 16%	10% to 72% Average 51%	10% to 44% Average 23%	5% to 20% Average 9.5%	30.0% to 42.0%

their series were not proved skull fractures but compare more with our series of severe head injuries with a mortality rate of 12 per cent.

About twelve years ago this author submitted a questionnaire to fifteen neurosurgeons. He ascertained that thirteen of the fifteen favored spinal drainage. The late Dr. Dandy and Dr. Sachs alone were opposed to it. A few authors, writing on the subject since then, have quoted Dr. Dandy as their reason for a lukewarm attitude toward the procedure. Cutler and Whitfield are the only authors to our knowledge who have joined the other two in absolute condemnation. In our opinion, the fact that "90 per cent or more of the profession" (Dandy<sup>5</sup>) continue to use dehydration and spinal drainage is the strongest testimony in favor of their values in management. Furthermore, the fact that 90 per cent of the authors writing on this subject today strongly favor spinal drainage is equally conclusive evidence of its value. The opponents of the method have published few mortality rates. Therefore, we must turn to published statistics and the analysis of large series of collected cases that deal with both treatment and mortality rates, in order to substantiate the claims of those who favor and to refute the statements of those who oppose dehydration and spinal drainage.

**Dehydration.** One notes in the literature a tendency to limit dehydration to the limitation of fluids and the use of magnesium sulfate per

ous possibilities will meet the crisis and obviate the need for so many lumbar punctures. However, if either of the two methods are to be neglected, he would favor less hypertonic solutions and more lumbar punctures. The use of magnesium sulfate administered intravenously and even sucrose carry more elements of danger than do hypertonic glucose solutions, therefore, the author is opposed to the former. From a clinical standpoint there is overwhelming evidence of the value of dehydration when carefully controlled and not used blindly or excessively to the point when the fluid balance of the body is dangerously deranged. Attention is again called to the fact that hypertonic plasma solutions, as used by the British during the war, may prove the safest and best hypertonic solution, when and if it ever becomes sufficiently available.

**Spinal Drainage.** If the general rule of close observation and frequent examinations is followed one will note sufficiently early those signs and symptoms which so strongly indicate the need for lumbar puncture and spinal drainage. The correct interpretation of these signs and symptoms early in this game of saving a life indicates the expertness of the player far more than his aptitude in inserting the spinal puncture needle. The dependence on and the correct interpretation of signs and symptoms will obviate the old teaching, seldom heard now, of routine lumbar punctures.

The nightmare of a herniated medulla ob-



longata through the foramen magnum has been impressed so vehemently upon the minds of the profession by a few opponents of lumbar puncture that the judgment of many has been warped. This fear has caused some to delay the spinal drainage forty-eight, seventy-two or

sion. Table ix, developed from the author's and the collected series of cases, representing good, average and poor management hospitals, shows that in the lowest mortality rates spinal drainage was used frequently and early during the first twenty-four hours. It also exemplifies the

TABLE IX  
SPINAL DRAINAGE IN FIVE HOSPITALS  
Time and Amount of Drainage and Mortality Rates

Source	No. of Cases	Gross Death, Rate, Per Cent	Lumbar Punctures, Per Cent	Punctures First 24 Hr., Per Cent	Average Amount Fluid Drained	Death Rate in Group 3, Per Cent
Author's.....	421	16.8	36.0	84	40 cc.	29
Hospitals A and B.....	184	18.5	70.0	80	40 cc.	21
Hospital H.....	1,342	28.4	32.0	60	28 cc.	37
Hospitals R and S.....	112	41.0	19.0	20	7 cc.	78

more hours until the patient is moribund. Then as a last resort puncture is performed. The ensuing death is either blamed on the lumbar puncture or, in reporting the given case, the surgeon states that the procedure did no good.

Delaying lumbar puncture when the signs and symptoms indicate its need is just as reprehensible as to delay operation for an early, very acute appendicitis. In witnessing a great many autopsies due to brain trauma this author has never seen a herniated brain stem that could be ascribed to the lumbar puncture. He has seen at least eight cases when the hemorrhagic, edematous brain, due to its own weight, has sagged downward into the only natural opening that permits expansion, viz., the foramen magnum. Such brains have a ring of edema and congestion comparable to the distal portion of a limb encased in a tight plaster cast. Every surgeon should fear the natural laws of weight and gravity in the instance of a water-logged brain far more than herniation of the brain from spinal drainage.

*When indicated, the earlier spinal drainage is performed the more life-saving it becomes.* The earliest possible relief of generalized cerebral edema, with its accompanying suppressed circulation and anoxia, is the aim of treatment. Spinal drainage of a sufficient amount of fluid, usually bloody, to make more room for the entrance of arterial and the escape of venous blood is the only method left unless we wish to return to the days of subtemporal decompres-

value of true drainage, regardless of the manometer reading, as compared with the removal of a small amount of fluid. How easy it would be for the surgeons who used the procedure in only 19 per cent of their cases, and used it late, to say spinal drainage was of scant value.

The strongest evidence of the value of spinal drainage is found in the article by Rowlette and Weiner,<sup>6</sup> written in 1941, and previously quoted by Mock and Mock, Jr. Their experiment consisted in assigning, in rotation, every patient with a skull fracture and a truly serious brain injury to two services in the St. Louis City Hospital for treatment. Unit A continued to treat these patients by no limitation of fluid, a very moderate dehydration and only an occasional spinal puncture. Unit B adopted the most radical dehydration for forty-eight hours and almost routine, early lumbar punctures with practically total drainage of all the spinal fluid at each tap, "as recommended by Fay." The mortality rate after three years for unit A was 37.3 per cent and for unit B 21 per cent. This article is recommended to those who still doubt the value of spinal drainage.

Group iv., the operative group, represents one of the great battle grounds of surgery. In 1896, Senn, in an unpublished article found in the Crerar Library, cried out against the almost routine practice of trephining skull fractures or suspected skull fractures. The early years of 1900 reveal authors writing about conservative management as opposed to trephining. In 1906,

Cushing wrote his memorable article on subtemporal decompressions in the presence of bursting types of fractures of the skull. This not only stimulated early x-ray of every head injury, the x-ray being a new and rather mysterious adjunct to surgery, but it revived operative treatment. In some clinics subtemporal decompression became more routine than spinal drainage is today. The mortality rates, which were already very high, climbed.

In 1920, Sharpe<sup>7</sup> wrote his book on "Diagnosis and Treatment of Brain Injuries." He gave a survey of hospital records showing that in six New York hospitals mortality rates for the decade prior to his publication ranged from 45 to 65 per cent in brain injury cases, "usually with skull fractures." He was a strong advocate of subtemporal decompression and showed the mortality rate lowered to 33 per cent by his methods.

Until 1930, there were the strong advocates of surgery and those just as strongly opposed to it. The latter turned to other methods, notably dehydration and spinal drainage. Dehydration was a new procedure and was undoubtedly overworked. The advocates of lumbar puncture became almost fanatical in demanding routine punctures in every patient with a head injury plus unconsciousness. Until the present time, controversy concerning surgery has continued to rage but to an ever decreasing extent. The great majority believe in and practice spinal drainage when indicated and believe in surgery for very definite indications. Conditions needing operations are depressed skull fracture, but not all slightly depressed fractures; compound fracture, practically all showing some depression; extradural hemorrhage; subdural hemorrhage and or subdural collection of fluid and conditions requiring subtemporal decompression or exploratory decompression; encephalography and plastic repair of the skull.

Even today there are those who advocate a much higher percentage of operations than is true with the average surgeon treating these injuries. The refinements growing out of their extensive experiences have greatly benefited brain surgery. However, we believe that operative rates over 10 to 12 per cent in the hands of the average surgeon is a trend toward radicalism and will increase mortality rates. Already the surgical profession has developed principles covering *when*, *where* and *how* to operate these cerebral injuries that were little recognized in

the early decade of this century. A few of these which have very definitely lowered mortality rates may be stated tersely as follows:

1. Early operations for skull fracture brain injuries are usually fatal.

2. The early subtemporal decompression is a thing of the past. This operation is seldom recommended today.

3. Compound fractures, especially those with visibly damaged dura and brain, require early and thorough débridement but must wait until the shock has subsided and the condition of the patient warrants the procedure.

4. Depressed fractures must be elevated but many a mild depressed fracture outside the motor areas recover and do well without operation. In the presence of a depressed fracture focal signs suggesting an underlying extradural and perhaps a subdural hemorrhage warrant operation as soon as its benefits outweigh its dangers to the patient. Otherwise, most depressed fractures can wait days before they are attacked surgically.

5. Extradural hemorrhages have a classical picture and should be operated upon when diagnosed. In this author's experience the signs and symptoms of extradural hemorrhage seldom develop in the early hours, they more often develop after twelve to twenty-four hours. When diagnosed operation must be done as an emergency procedure.

6. The acute subdural hemorrhage is still a controversial subject. Munro<sup>8</sup> and his followers believe that it occurs more often than is recognized and advocate early exploration, although not until the patient's condition warrants the procedure. Voris<sup>9</sup> and others believe that the risk of early operation of these acute subdurals is greater than to delay. By waiting, some of the suspected cases clear up either due to wrong diagnosis or because the hemorrhage was small and was absorbed. The others will wall off and can be attacked later as chronic subdurals. Practically all agree that this condition warrants sooner or later small exploratory craniotomy openings, usually bilateral.

7. General anesthesia is tolerated poorly by the acute brain injury patient. Local anesthesia can and should be used whenever possible.

To offset the war influence for more surgical management of brain injuries the author reproduces Table xA first published by him in 1931, and adds Table xB, to bring the skull fracture operative story of this century up to



TABLE NA  
OPERATIONS AND MORTALITY RATES  
From the Literature 1900-1930

Years	Total No. of Cases	Gross Mor- tality, Per Cent	Operative Data		Operations: Cases Under B Only		Oper- ative Mor- tality, Per Cent	Comment
			A No Data; No. of Cases	B No. of Cases with Data on Treat- ment				
					Number	Per Cent		
1900-1910.....	1,700	46.6	922	778	93	12.0	59.0	About 50% were basal sk. frs.
1910-1920.....	2,850	49.7	1,000	1,850	449	24.2	45.6	Many patients' were operated for subtemp- oral decompression only
1920-1928.....	4,099	33.4	90	4,009	587	16.0	46.6	Subtemporal decompres- sions still predominate
1926-1928.....	2,085	25.8	90	1,995	216	10.8	50.0	Tendency for more defi- nite reasons for opera- tion
1930, Author's cases	100	20.0	0	100	13	13.0	30.8	Skull fractures only
	10,834			8,732				

TABLE NB  
OPERATIONS AND MORTALITY RATES  
From the Literature 1930-1947

Years	Total No. of Cases	Gross Mor- tality, Per Cent	Operative Data		Operations: Cases Under B Only		Oper- ative Mor- tality, Per Cent	Comment
			A No Data No. of Cases	B No. of Cases with Data on Treat- ment				
					Number	Per Cent		
Swift—1932.....	190	26.0	0*	190	15	8.0	56.8	Serious head injuries and sk. frs.
Gurdjian—1933...	718	19.0	243	474	51	10.7	37.0	The 475 cases were proved sk. frs. with death rate 25%
Fay—1935.....	363	17.8	0	363	11	3.0	81.8	Serious head injuries, 23% sk. frs.
Furlow and Sachs— 1935.	192	23.0	0	192	96	50.0	33.3	16 (Class I.) operated early—16 deaths
Munro—1938.....	1,203	20.7	0	1,203	444	36.9	32.4	Craniocerebral injuries
Meredith—1940...	391	17.0	0	391	42	10.7	23.8	32% of these were sk. frs.
Author.....	331	16.8	0	331	36	10.8	27.7	Proved sk. frs.
	3,388			3,145				

\* 53 articles failed to mention any consecutive series of cases or any specific data on treatment.

date. It graphically portrays the earlier high mortality rates, the reduction in the same and especially the corresponding reduction in operative frequency and operative death rates.

### CONCLUSIONS

1. Proved or practically proved skull fractures are used in this article as a common denominator for comparison of reported and collected cases. Head injuries of varying degrees of seriousness will so dilute skull fractures and truly serious brain injury mortality rates that an unfair basis of comparison results.

2. Brain injuries and the few complicated skull fractures are used in evaluating the signs, symptoms and the treatment used. Emphasis is placed on the brain injury as the causal factor of death.

3. The cause of the injury, sex and age of the patients, as well as the location and types of skull fractures, are set forth in the collected cases to show that these are quite comparable and, therefore, do not influence the higher mortality rates in one series as compared with another.

4. With the wide distribution of brain injuries, the fact that 65 per cent occurred and were treated in communities where neurosurgeons were not available and with from 45 to 64 per cent of the deaths occurring in the first twenty-four hours, it is self-evident that this is chiefly a problem for the general surgeon.

5. The signs and symptoms indicate the type of treatment and can be so evaluated as to be of real prognostic value. Very close observation is necessary as these signs and symptoms change complexion both quickly and insidiously.

6. The mortality rates are either as low as 17 to 20 per cent, as reported by a few authors and as shown by the good management hospital group, or as high as 30 to 42 per cent, as reported in the literature and as shown by the poor management hospital group, depending upon the surgeon's judgment and ability to institute carefully controlled dehydration, early spinal drainage when indicated and operation only when the time and very definite indications warrant the procedure.

7. Failure to use the methods, fear of them engendered by controversy, failure to apply them early instead of waiting until the patient is approaching death and failure to observe proved principles concerning operations accounts for 10 to 25 per cent of the brain injury

deaths throughout the nation. This is a challenge to every surgeon.

8. The "neglect" in the doctrine of "watchful neglect" too often applies to both observation and treatment.

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### DISCUSSION

JOHN RAAF (Portland Ore.): Dr. Mock has collected a tremendous number of cases of cranio-cerebral injury and I agree with him regarding most of the conclusions he has drawn from this vast experience.

Certainly, the treatment of shock is of first importance. I have in mind the case of a teen-aged boy who received a head injury and remained in profound shock over a period of five or six hours. Finally, intravenous fluids were administered and he began to improve. Later he developed urinary suppression without any evidence of gross kidney damage and finally died with a mounting blood urea. It was thought that the profound prolonged shock was responsible for the urinary suppression.

I agree that children survive cranio-cerebral injury better than adults. I have been impressed how often a child who has sustained a head injury will present the picture of having an extradural hematoma, in that an hour or so following the blow on the head he will begin to vomit and become drowsy. There may or may not be localizing signs. I have been on the verge of operating to evacuate the hematoma, which I thought was present, but a little further delay has resulted in the child regaining consciousness and subsequently recovering completely without surgery. No doubt edema of the

brain in these children accounts for this picture. Fine judgment is required in such cases for certainly one does not wish to overlook an extradural or acute subdural hematoma.

Dr. Moek made one statement with which I am not in full accord, namely, "Constantly remember that during the acute state the specialist must go to the brain injury, not the brain injury to the specialist." Perhaps the disagreement hinges on the definition of the word "acute." I agree that if the patient is in profound shock he should not be moved. However, in the case of an extradural or acute subdural hematoma, I believe that it is very important to move the patient as rapidly as possible to a well equipped hospital where he can be operated upon and receive adequate postoperative care. In my opinion, an extradural hematoma is an extreme surgical emergency. I have seen perhaps five or six patients die of extradural hematoma within twelve hours after injury. Ten years ago when I was called regarding a patient whose history sounded as if he had an extradural hematoma, I would pack my surgical equipment and go to some neighboring town to operate. For two reasons I have come to the conclusion that this was wrong: First, the operation can be started more quickly if the patient is brought to the surgeon and sometimes an hour or so means the difference between life and death; second, the postoperative care of the patient who has had an extradural hematoma is extremely important and should be supervised by the surgeon who has performed the operation. A number of times it has been necessary to reopen heads in which the extradural hematomas have reaccumulated. Had these patients not been under my direct supervision (and this happened in one instance) they would have lost their lives from the recurrence of the hematoma.

There is one other point regarding extradural hematoma which I would like to make. I believe that one, two or even three burr holes may not be enough to dislodge the hematoma. I usually place four burr holes, at least on the suspected side, before I am satisfied that no hematoma is present. The following two cases are illustrative:

**CASE I.** An eighteen year old boy was thrown from a horse. The fourth burr hole high in the parietal area near the midline finally uncovered the extradural hematoma which had stripped the superior longitudinal sinus away from the bone and extended over to the opposite side of the head.

**CASE II.** An eleven year old boy, while riding a bicycle, was struck by an automobile. The extradural hematoma in this instance was far forward over the left frontal pole.

Neither the hematoma in Case I nor in Case II was small, and in my opinion, had these hematomas not been discovered and evacuated the patients would not have survived.

I agree with Dr. Moek that there are numerous signs and symptoms which will indicate whether the patient is getting better or worse. To my way of thinking the two best indicators are the depth of the coma and the height of the temperature. Deepening coma and rising temperature are alarming signs.

In closing, I would like to say that I am in complete accord with Dr. Moek's opinion regarding spinal drainage.

JOSEPH E. J. KING (New York, N. Y.): I want to thank Dr. Moek for his splendid paper and for his courtesy in sending me a copy of it. I have read it several times and enjoyed each reading.

The outstanding feature seems to me to be his approach to the subject by what we call common sense or horse sense, which is the best kind of sense in the world anyway. His teaching should be widespread because head injuries themselves are very widespread and distributed. There are not enough neurosurgeons in the United States to look after all these patients, therefore, the general surgeon must take care of many of them or most of them.

In order to do so they must be acquainted with these conditions and how to manage them, just as well as they know gastric, thyroid and other phases of general surgery. Dr. Moek's paper, if studied properly, will be of great help to anyone in the proper handling of these conditions.

I am glad he placed such emphasis on the therapeutic value of the lumbar puncture properly done. Lumbar puncture *per se* never hurt anyone. It is the removal of fluid in the wrong patients that produces the fatality. There is no place here for the discussion of the various kinds of operative procedures, so I shall say nothing about any kind of operation.

I should like to emphasize the apparent difficulty of making the diagnosis of acute and chronic subdural hematoma. The correct diagnosis is sometimes quite difficult to make. I should like to recall two instances of fine, high-powered medical friends of ours, both from Virginia. One of them lay around for three months with a subdural hematoma. His mentality was quite poor. They were going to ship him off to Florida or Arizona to get rid of him. Finally they made a diagnosis of left frontal lobe tumor. A little burr hole, as John Raaf spoke of, let out a lot of bloody water. Now he is going along quite well and is the author of one of our very fine books on medicine. That man was in the hands of some of the biggest doctors we have. The unanimous opinion was that none of them knew what was the matter with him until finally, after I was requested to see him, a burr hole was made posteriorly on the *right* side and a large amount of bloody fluid was evacuated. It was not of recent origin. The physician-patient, who was in a deep stupor, regained his consciousness in a few minutes after evacuation of the bloody fluid and inquired about

the membranes of the hematoma, condition of the convolutions, etc.

The other case was that of one of our distinguished colleagues who was in the same hands for three weeks. The nurse said that he could raise his right hand at times and at other times he could not. He had a large dilated pupil on the same side, the right side. I learned about his illness just before he died and went in and stood around with two other friends until he died. He was then moribund and had Cheynes-Stokes respiration. Autopsy

showed a huge, right-sided subdural hematoma about 1 inch thick from stem to stern and shaped something like a turtle's back. The diagnosis that had been made of that doctor's condition until the time of his death—for three weeks in the hands of all these big doctors—was written in the clinical record, upon which all of them agreed. That diagnosis was, "Allergy of the brain due to eating wheat muffins."

HARRY E. MOCK (closing): I have nothing further to say, except to thank the discussers.



# THE SYMPATHETIC REFLEX ARC AND ITS CLINICAL SIGNIFICANCE

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PHYSICIANS know that a blood vessel responds to irritation by local contraction, and they have long suspected that injury to the sensory nerve of an extremity initiates a sympathetic reflex which puts the collaterals of the vessel into spasm. Anatomists and physiologists, however, have been unable to demonstrate the mechanism. They would not admit the existence of a receptor sympathetic system in blood vessels. Clinicians, therefore, have been reluctant to accept the presence of a reflex sympathetic action. In the growing literature on arterial spasm, one finds reports aiming to show that the sympathetic plays no rôle whatever in arterial spasm, while other instances are reported to prove that the sympathetic is the possible transmitter of the spasm to the vessels. Such a discrepancy is due to the different interpretation of clinical phenomena and the absence of incontrovertible anatomic and physiologic facts. While some anatomists (Dolgo-Saburoff) claim to have identified intramural nervous apparatus with nerve cells in the vessel wall, others (Woolf) could not find them. Le Gros Clark is of the opinion that they do not exist; he claims that the connective tissue cells have been mistaken for ganglion cells. While Leriche<sup>1</sup> holds that vascular trauma initiates a local reflex by way of a special intrinsic mechanism, in his Hunterian lecture states: "An arc for any reflex via the sympathetic has not yet been found."

The interpretation of the word "reflex" is changed by our knowledge of tendon reflexes, as an immediate response to a stimulus with an immediate termination of the reflex at the end of the stimulation. The sympathetic reflex is not the usual kind; it is delayed for hours or even days after the reflex arc is set on, provided that the reflex has been set on repeatedly over a period of time. We must consider the presence of a self-sustaining element in a sympathetic reflex. Even a clonus does not always terminate the reflex when the stimulus ends. When a reflex focus

of irritation becomes well established even after the original exciting cause—the trigger—has disappeared, it is known as a reflex sympathetic dystrophy. This reflex dystrophy may be expressed by one or more characteristics of sympathetic disturbance, such as pallor, cyanosis, sweating, edema, atrophy of the skin or the so-called osteoporosis. Only interruption of the reflex arc by blocking segments of the sympathetic pathways may give relief in early cases.

Arterial spasm is known to have followed fractures of long bones when the main artery is irritated to a greater or lesser extent. You have all observed the absence of the pulse in the extremity for as long as an hour or more following manipulation of a fracture of long bones. The classical example of arterial spasm is the so-called Volkmann's ischemic contracture. We all know that the Volkmann lesion occasionally follows injuries of soft parts when no fracture is present. This lesion has also been observed after prolonged application of a tourniquet. As long ago as 1877 Esmarch suggested constrictors of soft rubber stating that the inelastic constrictor frequently caused gangrene of the extremity. That Volkmann's original theory that the lesion is due to tight splints is erroneous is well known. Cases of Volkmann's contracture have been seen when no splints were applied or any other external pressure exerted. Even simple embolectomy of the brachial artery is occasionally followed by a Volkmann lesion. We also know that nerve injury is not indispensable for the development of a Volkmann contracture. Experienced surgeons believed all along that spasm of the artery and reflex spasm of the collaterals are responsible for the Volkmann contracture, and only the arguments of anatomists and physiologists that there is no such a spasm militated against a general acceptance of this view. Barnes and Truetta<sup>2</sup> have actually demonstrated in animals the spasm that followed tight application of a tourniquet. They even showed a segmental spasm of the main artery

of the opposite limb. However, because of the obvious reduction of arterial blood supply after application of a tourniquet, their experiments with arterial spasm are not entirely convincing.

Using rabbits in my experiments I proved that an irritation of a main artery causes immediate contraction of the collaterals—the small arteries and arterioles. After the hair of the ear of a white rabbit is removed, the ear is fastened to a window on a board. A strong transmitted light permits easy observation of the change in caliber of the small vessels in the ear. When the common carotid artery of the same side is exposed and teased with forceps, it contracts immediately and at once the small arteries in the ear follow suit. When the irritation of the carotid ceases, the artery remains contracted for about ten minutes and then resumes its normal caliber. The arterioles of the ear dilate soon afterward. Thus, there is no doubt that vascular trauma initiates a local reflex spasm of the small arteries and arterioles.

We all know of numerous clinical observations which have defied rational scientific explanation. For instance, why do some patients faint when the pleura is punctured in thoracocentesis, or when a constrictor is applied to the arm preliminary to venipuncture? Why does hyperventilation induce a fit in the epileptic? Why does the voice rise in pitch in anger? Slowing of the pulse, extreme pallor, profuse sweating accompanying the fainting in thoracocentesis and venipuncture suggest cerebral anemia—vasoconstriction of cortical blood vessels. We know that a single deep inspiration causes arterial constriction; hyperventilation then causes constriction or spasm of the cortical blood vessels, thus precipitating a fit in the epileptic. The interrelationship between the cerebral and peripheral vasospasm explains the high pitch of voice in the angry; the blood vessels of the vocal cords contract causing the cords to shrink thus causing a higher pitch. All this reasoning assumes a sympathetic reflex arc extending to the cerebrum. To prove the presence of such a reflex arc I made use of the encephalograph.

Since to many electro-encephalography is an unfamiliar field, by way of introduction suffice it to say that just as electrocardiography records the electric potentials of the heart so does electro-encephalography record the electric impulse of the brain cortex. However, the electric discharges of the brain have a very

low voltage, about one-hundredth of the voltage in electrocardiography. There are three leading frequencies in brain waves; the alpha or medium wave, between 6 and 13 per second; the beta or fast wave, between 14 and 60 per second, and the delta or slow wave, between 1 and 5 per second. The typical electro-encephalogram of the normal adult shows about 9 to 10 waves per second, with an amplitude or voltage of 10 to 50 microvolts. Slow waves with a wide amplitude—delta waves—are registered over areas where the cerebral cortex is compressed by an expanding lesion or where there is some other interference with the blood supply of the cortex, as in cases with an embolus in the middle cerebral artery. Induced constriction of the vascular bed in the cortex, therefore, will be reflected in slow, delta waves. If the blood supply of the cortex is totally defective, all electrical activity stops and the brain waves flatten.

When during a routine encephalography venipuncture of the right antecubital vein was performed, it elicited irregular activity from the right frontal lobe, characterized by ragged high voltage waves, superimposed upon low voltage beta waves. The removal of the needle from the vein caused immediate return to the normal activity. During this experiment no alteration of activity from the left frontal lobe was elicited. (Fig. 1.)

Another experiment concerned a woman with cerebral arteriosclerotic manifestations. Tracings of the right and left parietal leads were made. A medium voltage fast activity was obtained from the left parietal lead and 10 to 20 per second low voltage activity in the right parietal lead. A tourniquet was then applied to the right arm. At once the waves from the right parietal lead became much slower and the amplitude much wider. Upon removal of the constrictor a return to the dominant rhythm was obtained. (Fig. 2.) A tourniquet was then applied to the left arm and immediately slow waves with wide amplitude were obtained from the left and to a lesser extent from the right parietal leads. The introduction of a needle in the cubital vein gave no added change in abnormality. As soon as the tourniquet was removed, an immediate return to the dominant rhythm was obtained. (Fig. 3.)

This immediate response of the vascular supply of the cerebral cortex to induced vasoconstriction in the arm is definite proof of the

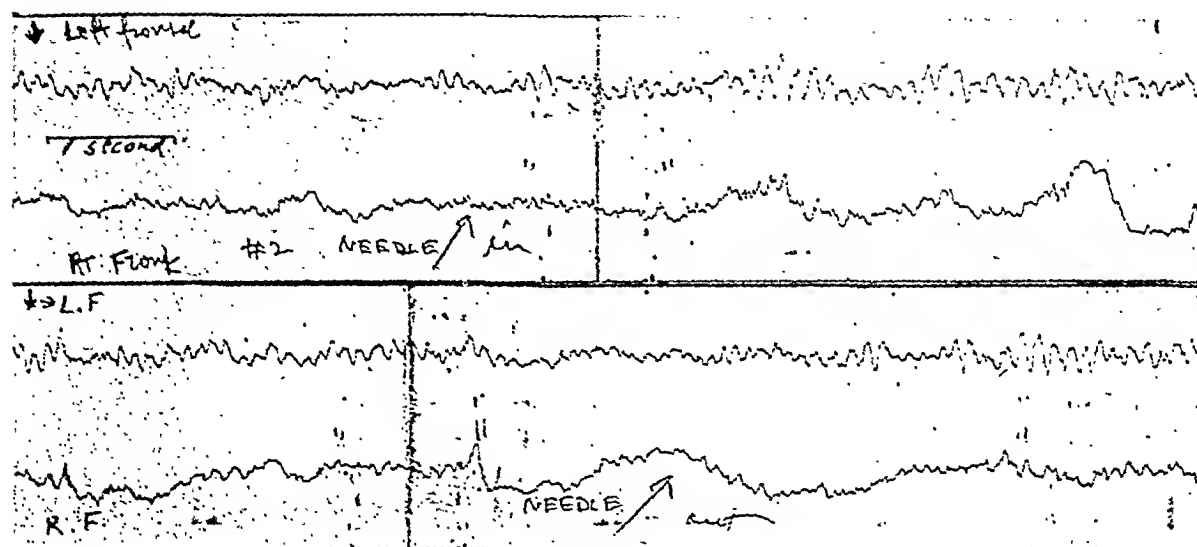


FIG. 1.

presence of an afferent reflex receptor in the vessel wall of the arm. Puncture of the cubital vein causes a local spasm of the vessel and an immediate reflex constriction of the cortical vessels; the application of a tourniquet to the arm, which results in a vascular spasm of the numerous blood vessels in the arm, leads to a pronounced spasm of the cortical vessels not only on the ipsilateral side but bilaterally. In the light of these facts, it is possible to explain an old observation of Galen in the second century A.D. that in local epilepsy, clonus spasms may be arrested by tying a band round the limb in which they start.

It is known that stimulation of the cerebral cortex causes a diminished cutaneous temperature on the contralateral side of the body and that the side of the body feels warmer to touch after the removal of the contralateral motor-

sensory area of one hemisphere. Our encephalograms show that there is also present a reverse reaction from the periphery to the center. Since spasm originating in the limb is at once reflected into a vascular spasm in the cerebrum and a spasm there leads to a spasm elsewhere in the body, it follows that a vascular spasm anywhere in the body sets off a chain of spastic reactions affecting the entire animal organism. The appreciation of this physiologic fact permits a better understanding of numerous baffling conditions which, for want of better understanding, we are in the habit of dismissing as being of "functional nature." To illustrate this point, I wish to mention here several typical cases:

A forty-five year old U.S. Navy Commander was suffering for years from attacks of epigastric pain ending in vomiting. Repeated

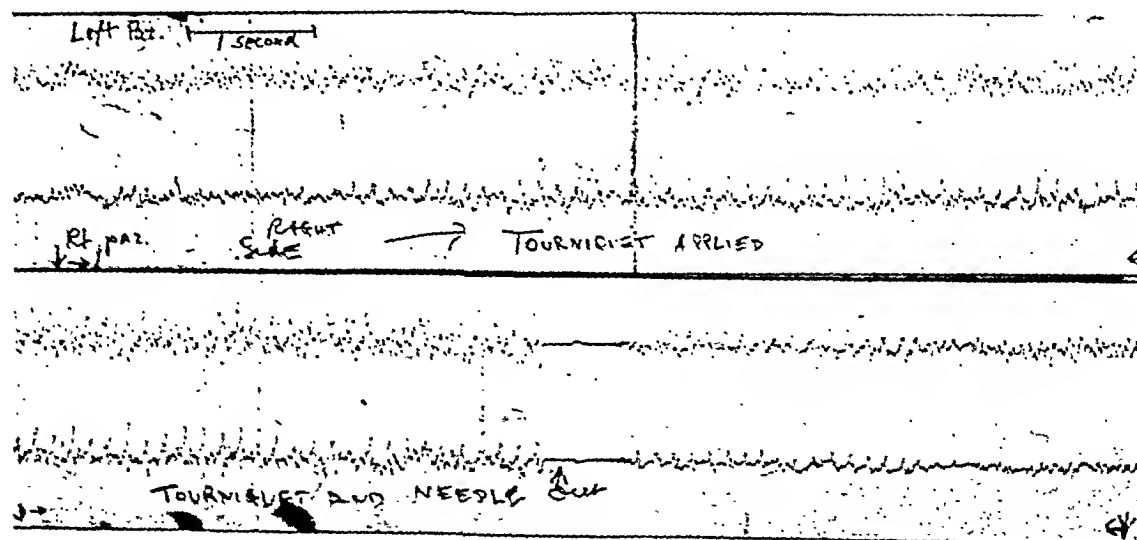


FIG. 2.

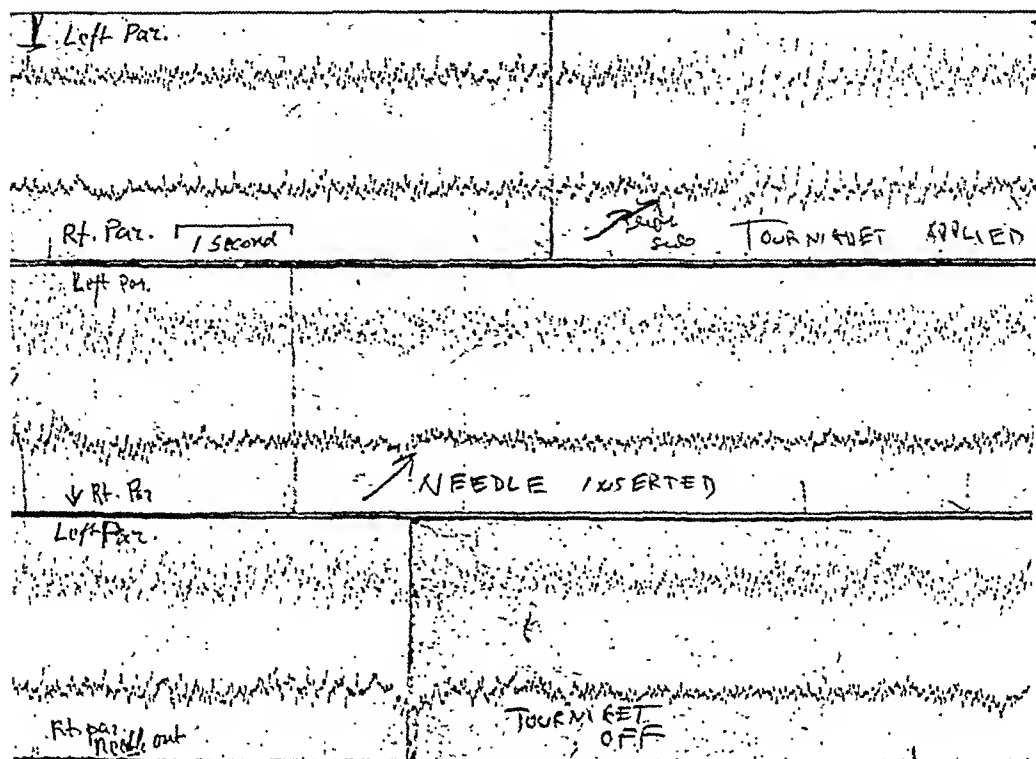


FIG. 3.

examinations revealed a pylorospasm of a "functional nature." Questioning of the patient disclosed that immediately before an attack of epigastric pain he suffered from paresthesias and vascular disturbances in the right hand, especially in the ulnar distribution. A cervical rib was found on x-ray examination and after a division of the anterior scalenus muscle and partial resection of the rib, the man has been free from the paresthesias in the right hand as well as from attacks of pylorospasm.

A forty-eight year old woman suffered an injury to the right index finger. Amputation through the basal phalanx left a painful stump covered with blue, cold, clammy, sweating skin, adherent to the bone. Gradually the pain from this stump commenced initiating attacks of precordial pain with all the characteristic features of angina pectoris.

A woman, forty years old, suffered for years from recurrent phlebitis of the left leg. However, there was no swelling of the left leg or ankle. After an attack of acute myositis of the lower back, the phlebitis in the left leg became exacerbated and the left ankle and leg swelled. This again subsided with the disappearance of the disability in the back. The spasm of the spinal muscles and their blood vessels led to a reflex spasm of the pathologic veins.

Finally, a personal observation. Recently the writer underwent a thoracic surgical operation. On the tenth postoperative day a phlebitis of the right calf manifested itself by localized pain in the calf, especially on standing and by a reflex pain in the right ring finger which was frostbitten years ago. Ordinarily, the pain in the ring finger would appear only in cold weather. When on the following day a ligation of the right femoral vein was carried out, the pain in the finger subsided immediately upon sectioning of the vein. With the involvement of the wall of the inflamed vein in the right calf, the vein ceased to be a vessel and became a diseased plexus of nerve fibers which initiated vasospastic impulses elsewhere by reflex action.

In all these cases the vasomotor mechanism is the main factor in the reflex development of the associated pathologic conditions. A vascular spasm at one point sets off a reflex chain of similar spasms throughout the body. It indeed appears that our present day approach to vascular spastic conditions is a faulty one. We have in the past considered as independent clinical entities such conditions as angina pectoris, migraine, vascular cerebral insult, Meniere's syndrome, idiopathic epilepsy, essential hypertension and pylorospasm. We should look at all these and other spastic



conditions as manifestations of the same pathogenesis, namely, vascular spasm, rather than as unrelated and independent clinical entities.

A number of common clinical observations by the writer supports this view of the intimate reflex interrelationship between vascular spasm in various parts of the body. Massage of the prostate immediately raised the blood pressure from an average of 120/85 before massage to 155/95, with return of the pressure to normal some fifteen minutes after the massage. Bimanual palpation of the uterus raised the blood pressure from an average of 115/80 before examination to 140/90 immediately after palpation. Venous pressure was measured as an index of spasm or narrowing of the vascular bed in cystoscopy. The venous pressure rose about 25 per cent when the cystoscope was passed through the male urethra. The pressure then returned to normal and rose again 20 per cent when the bladder was distended with the irrigating solution. After the catheter entered the ureter a new rise in venous pressure was observed. In other words every spasm about the urethra, the bladder and the ureter caused an immediate rise of venous pressure or narrowing of the vascular bed.

Present day conception of the sympathetic innervation of blood vessels of the limbs is based upon a series of four neurons: (1) Cortico-hypothalamic; (2) hypothalamic-spinal; (3) pre-ganglionic, and (4) post-ganglionic. This conception presupposes a decussation in the pons. My experiments do not support this view. *Not all* the post-ganglionic fibers destined for blood vessels join the peripheral spinal nerves. Many reach the main artery of the limb as direct branches from the sympathetic ganglia. We saw that application of the tourniquet on the right arm reflected first and most upon the right cerebrum and only secondarily on the left cerebrum. A vasoconstrictor impulse ascending from a spastic focus reflexly activates the whole ipsilateral sympathetic nerve supply and soon flows over to the sympathetic system of the contralateral side.

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# CAUSALGIA

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THE concentration of peripheral nerve injuries in centers by both the British and American Military Services early in World War II permitted the study of large numbers of patients with painful post-traumatic dystrophies by experienced men. Leriche, whose experiences are summarized in his monograph,<sup>1</sup> as early as World War I had shown that the sympathetic nervous system was intimately involved in these painful states, yet the pain mechanism has remained obscure. During the interval between World War I and World War II, numerous reports<sup>2-5</sup> verified the observations of Leriche, that interruption of the sympathetic chain would relieve the pain in true causalgia and the so-called minor causalgias, such as Sudech's atrophy and painful osteoporosis.

There has been much confusion concerning diagnosis, treatment and etiology of the causalgic states. Certain writers<sup>6,7</sup> have held that true causalgia, as originally described by Weir Mitchell,<sup>8</sup> Sudech's atrophy, painful osteoporosis and the so-called minor causalgias are but different expressions of the same underlying disorder, and indeed painful phantom limb has been included. Other writers<sup>9,10</sup> have been equally convinced that true causalgia is a clinical entity unrelated to the less severe states. For a time the writer found himself in this group, but with increasing experience this view has altered somewhat, so that now it is believed probable that the majority of the painful post-traumatic dystrophies, with the exception of painful amputation stump and true hysteria, are expressions of the same underlying disorder. The confusion which has prevailed and the wide differences of opinion which have arisen seem to have developed from the tendency on the part of various authors to pursue features of these syndromes that differ, rather than to seek a common denominator among them.

It shall be my purpose in this paper to present in summary the data from 105 cases of true causalgia seen in the military service and treated by sympathectomy (already reported elsewhere in papers by the author with Devine and with Ulmer<sup>12</sup>). These data appear

to permit support of the theory of Granit, Leksell and Skoglund<sup>14</sup> and of Doupe, Cullen and Chance<sup>15</sup> relating to the causative mechanism, namely, that it is a shunt of efferent sympathetic impulses into the sensory somatic fibers at the site of injury to the nerve.

In the 105 cases upon which this paper is based, a penetrating wound of large peripheral nerves was the causative agent in every instance. The nerve injury was incomplete in every instance. In an overwhelming majority of cases, the median or sciatic nerve was involved. The onset of pain was instantaneous in approximately 50 per cent. In the remainder the onset was delayed for intervals varying from fourteen hours to three months. None were associated with injury to the major blood vessels, and infection of the wound was rarely encountered. The ages ranged from nineteen to thirty-nine years. The disease was observed in approximately 5 per cent of all patients admitted to the Percy Jones General Hospital with wounds of peripheral nerves.

The outstanding complaint in each case was burning pain. Usually it was most intense in the autonomous zone of the involved nerve. While the pain was continuous, it was exaggerated by emotional and environmental stimuli. It was associated with vasomotor manifestations of two types, one vasodilatation and the other vasoconstriction. Generally the skin of these in vasodilatation was dry, scaly and warmer than the normal extremity, and the hair of this member was often long and coarse. The skin of those in vasoconstriction was usually cold, thin and glistening and sweated profusely. In this group there was usually loss of hair and tapering of the digits. Vasodilatation was a more common phenomenon than vasoconstriction. In a small percentage of the patients, no alteration in blood flow was noted.

Many patients obtained some relief of pain from the application of moisture to the painful part. If the extremity were in vasodilatation, cold water gave relief. If the part were in vasoconstriction, warm water produced comfort. Weir Mitchell<sup>8</sup> had believed that moisture was the factor which produced relief. Our own

observations indicated that the temperature was responsible. For patients in vasoconstriction with malarial fever were relieved during the bouts of elevated temperature, and this was confirmed when artificial fever was induced. On the contrary, patients who were in vasodilatation experienced exacerbation of the pain when the temperature of the painful part was elevated.

Emotional stimuli such as fear, anger, and/or disturbing noises produced exacerbations of pain. The slightest motion or touch of the part was painful. In the more severe cases, the patients' facial expressions reflected severe pain. They usually grasped the painful extremity just proximal to the wrist or ankle to hold it immobile. They would avoid emotional and environmental stimuli by seclusion in a dark room. As a rule they showed no interest in family or friends, even though they had been absent overseas for many months.

Many patients of this group were submitted to psychiatric interview after the pain was relieved by sympathectomy, and no evidence of predisposing constitutional factors was revealed. With rare exceptions, the individuals proved to be entirely stable. The high strung, tense individual appeared to experience more severe exacerbations of pain than the more placid types, however.

Approximately 20 per cent of the patients showed spotty osteoporosis of the small bones of the extremity. The remainder showed no change.

#### TREATMENT

Block of the appropriate sympathetic chain with procaine would produce dramatic relief. As a rule the relief following procaine injection would persist for one to two hours, or approximately the period that a local infiltration is effective. In a few cases the pain remained greatly reduced for prolonged periods after the injection. In none did it remain completely well, though many patients were given six to eight injections. This is in contrast to the experience of certain writers,<sup>4,13</sup> and indeed the author has observed lasting relief by this procedure in an occasional case of minor causalgia.

Neurolysis was done on many of these patients without relief. Periarterial neurectomy done at the level of injury on eight provided no relief. Periarterial neurectomy of the proximal portion of the vessel was not done. In six patients resection of the injured segment of nerve

was done, and complete relief of pain followed. In the remainder, relief was provided by sympathectomy. In nine patients, the initial sympathectomy failed to provide complete relief. In two of these in which the arm was involved, it was shown subsequently that the fourth rib had been inadvertently removed instead of the third and that the sympathectomy was incomplete. In seven cases in which the lower extremity was involved, some pain persisted after removal of the second and third lumbar ganglia. Sweating tests revealed that the sympathectomy was incomplete. In two of these removal of the first lumbar ganglion was sufficient to complete the sympathectomy and relieve the pain. In five, dorsal ganglia 11 and 12 were removed, after which the sympathectomy was complete and relief was provided. No patient was permanently relieved by repeated procaine blocks. Two patients previously discharged from other neurosurgical centers as cured by repeated procaine blocks subsequently developed a recurrence of pain after being transferred to the Convalescent Hospital attached to our unit, and these were treated by sympathectomy with relief.

The chief residual after relief of pain by sympathectomy consisted of stiffness of the small joints of the hand, which was attributable to prolonged disuse. It was frequently difficult to overcome. The other residual depended upon the extent of the nerve injury.

#### COMMENT

Among the theories relating to the causative mechanism in this disorder are infectious neuritis and fibrosis about the nerve. The fact that infection was rarely observed and the onset of the pain so often occurred at the moment of impact disproves this hypothesis, and the frequent early development of pain also disproves fibrosis about the nerve at the site of injury as a factor. The complete absence of vascular injury in this group eliminates this theory from consideration. Certain writers<sup>1,2,5</sup> have considered ischemia to be a factor. Others have thought that hyperemia induced the pain. However, many patients are observed in vasoconstriction, while others are in vasodilatation, yet the pain is relieved by interruption of the sympathetic chain. This would make it appear that the alterations in blood flow are the result of pain rather than the cause of it.

Psychogenic factors influence the pain remarkably but cannot be considered as the

etiologic agent, for many of the patients upon which this paper is based had withstood emotional experiences far greater than that of the wound without such complaints. Furthermore, when relieved of the pain, all evidence of emotional instability disappeared.

The spotty osteoporosis, considered a cardinal feature of Sudech's atrophy or painful osteoporosis, probably is not a causative factor in the production of pain, for it was noted in less than 20 per cent of the patients of this group, and my own experience would indicate that it is not a consistent finding in the minor causalgias.

In 1944, Granit, Leksell and Skoglund<sup>16</sup> recalled attention to the fact that there is a constant interplay of impulses between the sympathetic and somatic fibers of any mixed nerve. This interplay is greatly increased when a segment of nerve has been injured, probably as the result of fragmentation of myelin at the site of injury, and they advanced the hypothesis that the underlying mechanism in the causalgic states was a shunt of efferent sympathetic impulses into the sensory fibers at the site of injury. Doupe, Cullen and Chance<sup>17</sup> on the basis of clinical experience and laboratory evidence supported this view, and more recently White, Heroy and Goodman<sup>18</sup> have given added support, and the writer finds that his own observations are compatible with this view.

With rare exceptions, causalgia results from nerve wounds that are incomplete. The onset of pain may be instantaneous or may be delayed for several weeks. Excision of the injured segment of nerve always provides relief of pain, and complete sympathectomy of the involved part has provided relief in every instance of the writer's experience. Neither external nor internal neurolysis influences the pain. Periarterial neurectomy when done at the site of injury does not influence the pain. The author has had no experience with periarterial neurectomy done on the proximal portion of the vessel as advocated by Leriche.<sup>1</sup> However, it is not believed that periarterial neurectomy interrupts fibers that are not also included when removal of the appropriate portion of the ganglionated chain is accomplished, as has been suggested by Hermann, Caldwell and Reineke.<sup>3</sup> As has been pointed out by White, Heroy and Goodman,<sup>18</sup> the emotional and environmental factors which exaggerate the pain in patients with causalgia, and which in

the past were thought to be evidence that the disease was hysterical, have one common denominator, namely, the increase of the out-flow of efferent impulses from the hypothalamus over the sympathetic chain. The factors which provide relief of pain in the causalgic states, such as quiet or sleep, the application of warm water in vasoconstriction or cold water in vasodilation, are factors which reduce the out-flow of sympathetic impulses from the hypothalamus. The majority of the data, therefore, seemed compatible with the hypothesis that the pathologic mechanism of causalgia does indeed consist of a shunt of impulses from the sympathetic nerves into the sensory fibers at the site of injury to a mixed nerve.

It is difficult to explain on this hypothesis, however, the relief which is reported at times by one or more procaine injections of the sympathetic chain and the occasional failure reported by certain writers when sympathectomy was done. It is possible that the failure of sympathectomy to provide relief at times is due to an incomplete sympathectomy as the result of anomalous innervation when the lower extremity is involved, as has been shown in seven cases in this group, or to the inadvertent removal of the wrong rib when dorsal sympathectomy is performed, as has occurred in two cases in my own experience.

The spontaneous recovery which is observed in cases of causalgia may be due to the redeposit of myelin about the sensory fibers, thereby arresting the shunt. The relief which is reported for repeated novocaine blocks remains the most difficult phenomenon to account for. My own experience in the management of true causalgia suggests that the relief may be relative. A patient who is suffering intense pain may mistakenly regard himself as completely well for a short time if his pain is greatly reduced. It is also possible that repeated injections may hold the pain in abeyance sufficiently to permit spontaneous healing of the lesion.

It is not my purpose in this paper to discuss the minor causalgias. However, it is considered in order to state that the writer considers the causative mechanism in true causalgia and the so-called minor causalgias similar. It is probable that the differences are ones of degree. In true causalgia, with rare exceptions, the lesion is of a large mixed nerve and is the result of a penetrating wound, whereas in the minor causalgias, mild trauma about the small

joints is a more frequent cause. It is possible that the complaint of intense burning pain in true causalgia, as compared to a throbbing, aching pain in the less severe states, which is the chief difference, may be accounted for by the involvement of large numbers of superficial sensory nerves in one case, as compared to smaller nerves which serve tendons and ligaments in the other.

#### SUMMARY AND CONCLUSIONS

The data from 105 cases of true causalgia observed in the military service suggests that the painful mechanism of causalgia consists of a shunt of sympathetic impulses into the sensory fibers at the site of injury.

The diagnosis of causalgia can be established by block of the appropriate sympathetic chain with procaine, and it appears that repeated injections occasionally may provide relief. In the great majority of instances, however, appropriate sympathectomy should be carried out. For the arm, the dorsal preganglionic sympathectomy of Smithwick is the procedure of choice. When the lower extremity is involved, removal of ganglia L-2 and L-3 is effective in most instances. If this procedure fails to provide relief, sweating tests should be carried out to determine if the sympathectomy is complete; for in occasional instances, removal of the L-1 ganglion or the dorsal chain as high as D-11 may be necessary. While periarterial neurectomy unquestionably will provide relief in certain cases of minor causalgia or painful osteoporosis, this operation appears to hold no advantage over removal of the appropriate portion of the sympathetic chain, and it is more likely to fail. The risks and morbidity of the two operations are comparable. It is believed that treatment should be carried out early to avoid the crippling stiffness of disuse of the small joints and the psychic trauma of prolonged pain.

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#### DISCUSSION

JOHN W. DEVINE, JR. (Lynchburg, Va.): I have enjoyed this excellent paper of Dr. Mayfield's and wish to congratulate all of the essayists on their presentations this morning of this interesting and confusing subject.

My interest in causalgia started while I was a junior in medical school when a member of my family developed causalgia following an accidental gunshot wound of the median and ulnar nerves. I had the opportunity of studying in detail twelve other cases with Dr. Mayfield. I believe that we should limit our use of the term causalgia to severe painful extremities following gunshot wounds of peripheral nerves, as originally described by Dr. Weir Mitchell. I do not deny that the other conditions are not similar, but if we use this term in speaking of other types of painful syndromes, it confuses the picture even more. There were several conclusions that we came to regarding these patients, which I shall repeat. All of these patients were combat soldiers returning from long tours of

overseas duty. They were interested in only one thing, getting relief from this unbearable pain. They were not interested in leave, pay or even in the opposite sex. All were relieved by novocain injections of the sympathetic ganglion for the duration of the novocain anesthesia only. They all had vasomotor disturbance, which was manifested by vasodilatation or vaso constriction.

Why they occurred in some cases, and not in others, and why some of them cleared up spontaneously has not been explained. Adequate sympathectomy gave these carefully selected patients relief. I cannot agree that the explanation of this has been explained as yet. In this regard, I would like to comment that I have been impressed with the fact that the neighboring lymphatics were greatly enlarged at the time of the sympathectomy. It has occurred to us, but we were unable to prove it, that this might be an inflammatory process we were dealing with. An inflammatory process is one of the few pathologic conditions that occasionally clears up spontaneously. Interrupting and removing the sympathetic ganglion cures this condition and yet patients who have had a sympathectomy and splanchnicectomy for hypertension often have severe excruciating pain from intercostal neuritis, even when the intercostal nerve is cut at the cord. Certainly these patients have had an adequate sympathectomy and many of them have very severe pain which is similar to causalgia.

Regardless of what the etiology of this syndrome is, a great contribution has been made, since sympathectomies relieve the pain in this disease. Even, if we do not know the physiology and pathology of this condition, a great advancement has been made in that we were able to relieve the suffering in these pathetic patients.

ELISHA S. GURDJIAN (Detroit, Mich.): I just wish to say, Mr. President, that to paraphrase Dr. Coller when he discussed the paper by Dr. Elkin on 400 cases of arteriovenous aneurysms of the trunk and extremities, all of us put together probably will not see 107 cases of true causalgia in twenty years of practice. It is rather interesting that Dr. Elkin, in these traumatic arteriovenous aneurysms, did not use sympathectomy or sympathetic blocks before operation.

I would like to ask two or three questions. Was the spotty osteoporosis seen in those patients who had vasodilatation with peripheral resistance, or was it equally divided among those with vasoconstriction as well as vasodilatation?

Second, if sympathetic block and T.E.A. block does not help the patient, should one go ahead with sympathectomy in some of these cases?

Third, how about these so-called minor causalgias, patients whose hands look perfectly normal even though a portion of the phalanx has been removed, who complain bitterly of pain and who usually are compensation cases? And how about

this group of cases that we all see, who will go from doctor to doctor, and who are not aided by T.E.A. block or block of the sympathetic ganglia? What is the management of these cases? Does he have any experience in the matter of sympathectomy in this group?

FRANK H. MAYFIELD (closing): I wish to thank Dr. Devine and Dr. Gurdjian for their discussion.

Dr. Devine has raised the question of inflammation as a possible etiologic factor in causalgia. I believed that I made my view clear in the paper. The fact that the great majority of patients with causalgia develop symptoms immediately at the moment of impact eliminates inflammation as an etiologic agent.

Dr. Devine has also raised the point that spontaneous recovery occurs only in inflammatory disease. I would like to draw his attention to the matter of traumatic injury of the myelin sheath. Trauma will fragment myelin; however, it is capable of spontaneous replacement.

In regard to his remarks concerning the postoperative pain in patients who have had sympathectomy for hypertension, I must state that I have seen no patient in whom the postoperative symptoms resembled causalgia. It is true that many have postoperative paresthesias and also aching pain, but I do not believe that they can be classed with causalgia.

Dr. Gurdjian has asked a very pertinent question concerning the relation of osteoporosis as demonstrated with x-ray to the status of the blood flow in the affected extremity. It was our impression that those patients who showed vasodilatation in the involved extremity were more apt to show osteoporosis than those with vasoconstriction. Unfortunately, we do not have documentary data in regard to this that are reliable.

Dr. Gurdjian has also asked what our plan of management is in those patients with painful post-traumatic dystrophies who are not relieved by novocain block of the appropriate sympathetic chain. I presume that this question was prompted by material presented in other papers in the symposium which, unfortunately, I failed to hear due to the late train. I am convinced that diagnostic novocain block is essential in causalgia and in the so-called minor causalgias, and that one is not justified in performing a sympathectomy on an extremity for the relief of pain unless a preliminary diagnostic block has been done and has been effective. Furthermore, we regard with considerable skepticism patients who obtain prolonged periods of relief after block of the sympathetic chain with procaine. For the most part we have depended upon the psychiatrists for help in that group of patients who do not obtain relief with procaine block, and we definitely believe that the painful phantom limb falls into an entirely separate category.



# RÔLE OF THE SYMPATHETIC NERVOUS SYSTEM IN TRAUMATIC SURGERY

AS APPLIED TO FRACTURES, CAUSALGIAS AND AMPUTATION STUMPS

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THE present conception of opinion is that the sympathetic nervous system functions through a reflex arc. The reflex arc appears to carry sensory pain fibers and motor fibers to the arterioles and possibly lymphatics. Sympathin and adrenalin possibly act as boosters to the sensitivity of the sympathetic system with actual stimulation arising from the vessels in the neighborhood of trauma or as a result of pathologic changes in vessel walls such as atheroma or thrombosis.

Interruption of the reflex arc inhibits sensations of pain; whereas stimulation enhances pain, constricts the arterioles and produces a blanched, cold, moist, edematous limb with poor capillary response. If, however, under conditions of stimulation the sympathetic is interrupted, the response is a painless, warm dry limb with excellent capillary response, with return to better than normal color and gradually subsiding edema up to seventy-two hours.

*Interruption of Sympathetic.* 1. Tetraethylammonium chloride administered intravenously 3 to 5 cc., gauged by fall in blood pressure, in a 20 per cent solution, begins to work in about fifteen seconds with a maximum effect in fifteen minutes. This lasts about thirty minutes but gives relief of pain for about one to two hours.

2. Lumbar sympathetic block or dorsal sympathetic block, using three to four needles to administer (1) 2 per cent novocain, (2) 1 per cent procaine, (3) proctocaine or xylocaine and (4) absolute alcohol. The latter is more lasting and satisfactory but has the danger of producing an alcohol neuritis if carelessly administered.

3. *Ramisectomy and Ganglionectomy.* (1) Ramisectomy is advised for upper limb lesions; (2) ganglionectomy is advised for lower limb lesions, taking care not to remove the fourth lumbar ganglion. Ramisectomy and ganglion-

ectomy are recommended procedures whenever possible, irrespective of response to sympathetic block procedures or tetraethylammonium.

The thermacouple and oscillogram are not necessary to gauge response. The well trained surgeon's hand can detect (a 2-3) degree change in rise of temperature, plus dryness of extremity and response of capillaries to compression of thumb on the plantar surface of the great toe.

*Response to Trauma.* The physiologic and pathologic pre-existing status of an individual plays a very important part in the presence of trauma; eg., (1) the healthy young agile individual versus the aged arteriosclerotic; (2) the individual who is a clotter versus the hemophilic; (3) the individual with sympathetic imbalance—anxiety status (moist, cold with poor capillary response); (4) those with, (a) Raynaud's syndrome, (b) Buerger's disease, (c) vasospasm, (d) acrocyanosis (e) livido Reticularis, (f) erythromelalgia, (g) intermittent claudication syndrome and (h) arteriosclerotic diabetes.

Unfortunately in traumatic cases, in general, we are confronted by a new patient, who makes his first appearance shrouded by pain, mental anguish and shock. Nevertheless, as the patient is investigated we must not forget the possibility of any of the pre-existing vasomotor disturbances, so as not to be taken by surprise when the injured extremity becomes cold, blanched, edematous or shows impending gangrene. All are aware that some patients develop acute bone atrophy, others have more than usual pain, while some develop a very extreme edema and fortunately only a few cases of impending gangrene. The above responses do not bear any relation to the severity of the lesion; in fact, they are more frequently associated with less severe trauma. I believe

that an explanation of these phenomena can be explained on the basis of pre-existing vasomotor changes, with, in some cases, a blood dyscrasia, allowing intravascular clotting in vessels of diminished caliber. The latter offers an explanation for the so-called traumatic phlebitis which we all admit does exist.

*Refrigeration versus Interruption of Sympathetic.* Refrigeration will inhibit pain, reduce edema and produce dilatation of the capillaries. When, however, the refrigerated limb is allowed to approach room temperature, the response is acute and excruciating pain, and massive edema with blebs and fever.

In short, refrigeration should be used only in cases in which amputation is inevitable. Interruption of the sympathetic inhibits pain, prevents or reduces the edema and produces vasodilatation, temperature rise and dryness. Another phenomenon develops, situated at the junction of ice and air, or rather just above the area of refrigeration which resembles venous thrombosis. In patients refrigerated for several days the skin in this area undergoes necrosis or if incised for amputation purposes undergoes necrosis. We have prepared sections of these areas and found to our surprise that we were not dealing with venous thrombosis but dilated vessels and venous stasis. Based on these findings in cases requiring prolonged refrigeration, for constitutional reason we have modified our technic? Refrigeration is carried only to the mid-calf when amputation is considered above the knee and the actual amputation is carried out under cyclopropane anesthesia.

*Fractures and Crush Injuries.* Interruption of the sympathetic nerves as soon as possible after injury releases pain, inhibits or reduces edema, overcomes blanching of extremity and allows a moderate amount of active motion. The response to tetraethylammonium is remarkable, but not so lasting or dramatic as alcohol block or sympathectomy, but nevertheless is well worth while. Sympathetic interruption enables reduction of a fracture with marked edema in about seventy-two hours, instead of a delay of seven to ten days with elevation of the extremity at room temperature.

In crushing injuries to the hand and foot, we are all aware of the degree of temporary disability and the vast lapse of time in rehabilitation. I urge early and complete sympathetic interruption in these cases. In my experience

the results have been most remarkable. These patients derive a sense of well-being with only one-third of the convalescence.

CASE 1. Miss E. R., age forty-nine suffered a crushed right foot caused by a bus tire. Etamon, 3 cc., reduced her blood pressure from 190/80 to 87/60; it stopped the pain for one hour and was repeated daily for three days. The skin became wrinkled and the edema subsided. The patient walked in elastoplast in fourteen days and ten weeks postoperatively the blebs and ulcer base healed. In eight weeks no edema was present and there was only slight limitation of dorsi flexion (no bone atrophy).

*Traumatic [Thrombophlebitis and Phlebotrombosis.* Interruption of the sympathetic in conjunction with anticoagulants should be used prior to thrombotomy and venous resection and the latter resorted to only in selected cases.

*Acute Bone Atrophy.* Periodically, and fortunately not too often, we are confronted with a hand or foot, glossy and edematous, slightly cyanotic, over which the patient has very little active movement. The x-ray reveals acute bone atrophy. Passive manipulation enhances the condition whereas interruption of the sympathetic produces astounding results in twenty-four hours. I will not discuss periarterial sympathectomy versus ramisection or ganglionectomy as space does not permit. The maltreated case with prolonged aggravation becomes psychoneurotic. This type should not be submitted to interruption of the sympathetic and may require amputation.

*Causalgias.* Causalgias, in my opinion, follow minor injuries to extremities or trauma to major nerves in individuals with a pre-existing sympathetic imbalance. Saw cuts or frost bites to digits frequently produce a typical causalgic pain. I can recall three sawyers and one teamster, all of whom developed a severe causalgia, necessitating loss of time from work. They all responded to ramisection, resumed work in three weeks and remained free of pain.

*Amputation Stumps.* The phantom limb or the causalgic stump is rarely seen if amputation is carried out with care. When sympathectomy is indicated it should be carried out prior to amputation. Contraindications should be mentioned in the case of an associated cellulitis of the limb to be amputated, other-



wise the metabolism will be raised and amputation will of necessity have to be taken higher.

We have not experienced any cases of phantom limb in the use of refrigeration anesthesia or refrigeration preparation prior to amputation.

*Technic of Operation.* For an upper limb we use ramisectomy rather than stelleectomy; for a lower limb lumbar ganglionectomy, through the back (1-2-3) is employed.

#### CONCLUSIONS

1. Interruption of the sympathetic will play a great rôle in traumatic surgery, more especially those with a pre-existing sympathetic imbalance.

2. The crush injury has been discussed.

3. Sudek's atrophy can be relieved of pain and the bones re-calcified.

4. Traumatic phlebitis has been referred to.

5. Refrigeration methods versus sympathetic interruption are discussed.

6. Fractures with massive edema may be reduced and placed in plaster seventy-two hours after sympathetic interruption instead of ten to fourteen days.

7. The remarkable results upon causalgias have been referred to.

8. Sympathectomy in amputation cases brings forth a debate.

9. Technic of operation were referred to with special reference to my posterior approach to the lumbar ganglia utilizing the lower part of the sympathectomy and splanchnicectomy incision.



# SURGICAL TREATMENT OF CAUSALGIA

## CASE REPORT\*

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THE patient, J. C., a Canadian infantryman, was wounded by a shell fragment in March, 1945.

He sustained a jagged wound of the back of the left thigh, which exposed but did not sever the sciatic nerve. The wound was débrided in a forward Surgical Center within six hours of wounding. The note made at the time states that there had been moderately severe bruising of the sciatic nerve but that there was no paralysis.

Forty-eight hours later the patient began to experience an acute burning pain in his left heel, which was not relieved to any appreciable extent by opiates.

Secondary wound closure was carried out at the base, and he was later evacuated to U.K. to the Neurological Center because of the causalgia. He had become very emotionally disturbed and was very difficult to treat, since he detested any physical contact whatever, stating that it aggravated the pain in his heel. He had also made the discovery for himself, that by picking up a glass of ice water and keeping his hands chilled minimized the pain in the heel.

A number of lumbar blocks were done, which gave temporary relief, and he was sent back to Canada. He unfortunately was "lost" for a time by those who had treated him in England, and no further real treatment was given. He had by this time become so hysterical that he was sent to a psychopathic ward for a while.

After being "found" again, he was further treated by lumbar blocks, and when his condition had been improved selective blocks were used to determine which ganglia it would be necessary to remove. It was found that he could be completely freed of his pain only when L1, 2, 3 and 4 were blocked.

The most striking thing when first seen by the writer was the dramatic change wrought by this procedure. The patient, who beforehand was a cowering, half sobbing, incoherent travesty of a man, continually wringing cold water over his hands from a piece of cloth kept moist from a bottle (a procedure which had produced marked maceration of both palms) became a smiling intelligent human being, who would give a coherent history, move about, shake hands and even permit his hair to be cut.

On the basis of these tests it was decided to do a thoracolumbar ganglionectomy removing L1, 2, 3 and 4, and to play safe, on the basis of some recently published reports, T11 and 12 as well. This was done in March, 1947, two years after his wounding. The operation was carried out as a one-stage procedure, with complete and permanent relief of his pain to date.

After his recovery from this operation, I sciatic nerve, which had been caught in the scar of his wound, was dissected out and freed. This was done for two reasons; (1) there was some weakness of dorsi-flexion of his foot, and (2) to attempt to prevent recurrence of similar symptoms, or the setting up of some other syndrome, by irritation of the sciatic nerve. He is at present symptom-free and his foot weakness is decreasing.

## DISCUSSION OF PAPERS BY DR. KOLODNY, DR. PRETTY AND DR. ELDER

FRANKLIN JELSMAN (Louisville, Ky.): In reference to the paper, "The Sympathic Reflex Arc and Its Clinical Significance," by Dr. Kolodny, I wish to commend Dr. Kolodny upon his efforts to understand better the principles of causalgia. We are definitely in need of this information. When the literature has been thoroughly investigated and the new texts that are available have been studied, one will find that there is very little detail, very little definite information and very little in the way of facts concerning the mechanism that is related to the production of causalgia or the pain that we know occurs in this syndrome.

As a result, we have many explanations, most of which are of a completely presumptive character. There has not been so far an anatomic explanation for causalgia. It still remains a matter of theory.

In the few minutes I have available, I would like to review briefly for you what some of the neuro-anatomists think about this problem.

Rasmussen thinks that there are definite sensory fibers supplying all blood vessels.

Clark, in his newly revised edition of Ransom, speaks of vasomotor fibers as sympathetic fibers. He speaks also of the visceral afferent fibers supplying the blood vessels. In this way, we have a definite reflex arc.

Now, just what happens in the production of pain with this sort of a mechanism is not known,

\* A film was shown of this patient during the delivery of the paper.

but it is thought that there is an injured sensory fiber in the periphery. This fiber, or injured area, sends up a barrage of sensory impulses to the brain. This barrage of sensory impulses may distort the ordinary sensory pattern and cause a short-circuiting of the impulses to other portions that ordinarily would not receive the impulse. The somatic motor fibers are stimulated. The autonomic efferent fibers or the ordinary sympathetic fibers are stimulated, and then the continued barrage of sensory impulses to the brain and the continued barrage of motor impulses from the hypothalamus causes a peripheral change. After a while this will produce a definite reflex that is independent of the original reflex or independent of the original source of injury.

There are some who believe, and I am inclined to agree with them, that the central mechanism plays a very important part in causalgia, either because of emotional impulses, because of the individual's natural tendency toward emotion (and some are more emotional than others), or because of a continued barrage of sensory impulses. The person becomes nervous and emotional and there is a group of impulses sent from the hypothalamus to the periphery, the injured nerve, and here it may be short-circuited again to a sensory nerve and carried back to the brain itself.

I would like to mention one thing in the use of sympathectomies. I think it would be a good idea to save the first lumbar ganglion, if at all possible, and also, in the use of tetraethylammonium chloride, intramuscular injection is probably better than intravenous injection for chronic pain such as causalgia.

ELISHA S. GURDJIAN (Detroit, Mich.): In discussing Dr. Kolodny's paper, I, too, am impressed by the fact that it is through efforts of this type that some of the hitherto unexplained mechanisms will be answered with consequent better management of difficult cases.

I was particularly interested in the electroencephalographic records that Dr. Kolodny showed. The changes that he describes were also obtained in seven or eight of our patients in Detroit. Some of the changes occurred on the opposite side from the body part stimulated. A few of the patients also had changes in the electroencephalogram on both sides. Most of the records show inhibition of the repose rhythm, as he stated.

I think that Buerger and many other electroencephalographers since his time have attributed this sort of phenomenon to the volley of electric impulses from the extremity or other parts of the body to the brain, with consequent inhibition of the ordinary rhythm of the brain or the repose rhythm of the brain, so that there is an inhibition for two to five seconds following such an impulse from the periphery. Opening of the eyes and closing of the eyes, turning on a light and turning off a

light and various other things can cause this phenomenon.

However, the explanation that Dr. Kolodny gave, of a possible vasomotor mechanism associated with vasoconstriction in the brain, is interesting and certainly should be looked into very carefully.

However, the vasomotor tone of the central nervous system is not the same as the vasomotor tone of the peripheral circulation. For instance, certain drugs such as carbon dioxide will cause vasoconstriction in the periphery and vasodilatation in the central nervous system. Other drugs will do the same thing. It is a good thing that the vasomotor tone of the brain is difficult to disturb as easily as that of the peripheral system because if the vasomotor tone of the brain were as easily disturbed as the vasomotor supply of one's face (such as redness or pallor), you and I would be fainting many times a day. With this factor of protection, the organism carries on satisfactorily.

All of this may be taken as evidence possibly that the changes that Dr. Kolodny has obtained are due to peripheral stimulation with electrical volleys inhibiting or stimulating the brain wave rhythm rather than due to variations in the tone of the vasculature of the brain in connection with changes in the tone of the vasculature of the periphery. I think that his paper is very stimulating and very interesting.

RONALD W. ADAMS (Boston, Mass.): These papers have been so well and ably presented to you that your discussor finds it difficult either to add or challenge the statements of the authors.

I confess to a certain amount of bewilderment though on the facts of life as they concern the blood supply in the extremities affected by reflex dystrophy. Dr. Kolodny and Dr. Pretty have ably told you how vasospasm, arteriolar spasm, is the big factor, and yet, in the literature we find the reports of De Takats and Miller, who have studied the problem extensively and who tell us that in the well established reflex dystrophies, there is an increased blood flow to the affected part, as much as 30 per cent.

Quoting from an article that they wrote,<sup>1</sup> "This remarkable increase, persisting over many months and years, is the most characteristic feature of the syndrome. This is true even in those limbs which appear cold to the touch and with shiny, atrophic skin."

The same writers, however, say their patients had a further increase in blood flow following paravertebral block. In the true causalgias, I think I am right in saying that Mayfield and Devine published blood flow studies in their patients, and this was not necessarily true in their group. Some of them had an increased blood flow, others showed a decrease in the blood flow. They also reported cases in which the pain disappeared

<sup>1</sup> Arch. Surg., 46: 469-479, 1943.

with the presence of a hyperpyrexia, such as during the high temperature phase of a malaria attack. Perhaps Dr. Kolodny can tell us the mechanism there involved.

Our experience bears out that of Dr. Pretty, that paravertebral procaine block in the presence of an edema following fractures permits us to perform definitive treatment earlier, and it goes without saying that we prefer to reduce our fractures as an emergency procedure before edema is established.

Our experience with the sympatholytic drugs has not been too extensive. We have not used them for acute vasospasm and arterial spasm. We have used them in the reflex dystrophies but are not quite as favorably impressed as the Ann Arbor group of Barry Campbell, Lyons and others, who have used tetraethylammonium in the reflex dystrophies. Perhaps they have been able to teach their surgeons and residents to recognize the symptoms and signs at an earlier date than we have been able to, or perhaps they have been more persistent in their therapeutic program. We shall continue to use it in selected cases.

Procaine injection, when the symptoms have been well localized to a trigger point, has worked well in our experience, while paravertebral procaine blocks, singly or in repeated doses, have controlled a large number of our patients who present a well established reflex dystrophy. An occasional patient has been found to require ganglionectomy. Our attitude toward it is perhaps rather aptly expressed in a remark of John Homans, who, in discussing this subject, wrote, "Sympathetic ganglionectomy of the White and Smithwick type is a last resort. Those very familiar with it have little patience with less radical procedures. There is a satisfaction in curing the patients with the least possible expenditure of energy, which, I beg to say, is not laziness but artistry."

W. E. MISHLER (Cleveland, Ohio): These were very excellent papers. I have nothing to add to the discussion except one practical point, namely, the recognition of causalgia is rather simple and is universally done, but is done late.

I think the plea should be made that inasmuch as trauma is always accompanied by sympathetic reflex mechanism, the measures for the prevention of late results and the early institution of treatment are a "must" in the handling of traumatic cases.

JOSEPH E. J. KING (New York, N.Y.): I want to thank Doctors Kolodny, Pretty and Elder for their splendid presentations. Just think what a fine era we older fellows have lived in and what has been done, especially by the surgeons, for the relief of pain in our time. In the first place, I think that the prime duty of the physician in earlier times was to relieve pain. Dr. Weir Mitchell knew just as much about causalgia at the end of the Civil War

as anyone does today, except how to relieve pain permanently.

In passing, one must mention the names of Dr. Charles Frazier and Dr. William Spiller, who instructed us on how to relieve the terrible pain of major trigeminal neuralgia, which has nothing to do with the subject this morning. In recent years a number of good men, such as you have seen and heard this morning, have solved the problem of the terrible pain of causalgia, and the procedure has become commonplace and is universally accepted.

I well remember an old man at Bellevue Hospital in 1923 who had had a large, adherent lipoma arborescens removed from the inner side of his arm by Dr. Tom Russell of Post-Graduate Hospital, New York. Later the patient came to Bellevue Hospital with a terrible causalgia. The median, ulnar and musculocutaneous nerves were embedded in scar tissue. We did not know what to do except what we knew at that time. We did a neurolysis and that helped him a little. The pain recurred. The man could not sleep and was in terrible pain. Dr. Hartwell made me cut his ulnar nerve and free his median again. That did no good. Dr. Hartwell amputated his arm just below the shoulder, and that did not help. My associate, Dr. Klenke, made an incision over the vertebral column to cut the roots of the nerve. That helped him a little, but the only thing that gave him real relief was when he got pneumonia and died. We knew nothing about sympathectomy in those days.

Now, that operation could be done so easily by any of these men who have talked to us this morning. I want to ask any of the men who read these papers what their experience has been with erythromelalgia, and, second, has anyone been forced to perform cordotomy where sympathectomy has failed?

W. K. LIVINGSTON (Portland, Ore.): There are two things that pleased me very much this morning. One was the expression of clinical interest, by an organization of this type, in the influence of the sympathetics on surgical problems. The second was evidence of an experimental approach, such as brought out by Dr. Kolodny's paper. I was also in favor of Dr. Gurdjian's caution in the interpretation of these experimental findings. But we see in some clinics, I think, an excellent utilization of the experimental possibilities in sympathectomy. Bronson Ray is doing some beautiful work in New York with his sympathectomized cases in studying the sensitivity of the alimentary and genitourinary tracts.

There are two points that I would like to mention here that supplement this experimental approach: First, the concept of a vicious circle, if you will, or a cycle of activities set up within integrated neuron systems that becomes self-

sustaining. It has been beautifully exemplified in the work that is being done in experimental Jacksonian epilepsy. There is one other experimental finding from the physiologic laboratory that has a bearing, perhaps, on this remarkable phenomenon we saw in the film, of sensitivity of the skin, expressing itself with added pain in the causalgic area. That was an experiment of Taylor and Porter in Texas, a simple example of "facilitation" which they believed had some bearing on the excessive skin sensitization in causalgia.

They were trying to show how relatively innocuous stimulation can add centrally to reflex activity. Their setup was this: A spinal cat, in which they were stimulating (with each artificial respiration) the posterior tibial nerve and were recording contractions of the anterior tibial muscle. Therefore, they were producing in this spinal cat a reflex. They reduced their electrical stimulus to the minimal amount which would produce a bare contraction of this anterior tibial muscle with each stimulation.

Their record would show on a recording kymograph these minimal contractions of the anterior tibial muscle produced reflexly. With this setup, they dropped cold water repeatedly on the cat's foot. Immediately the reflex contraction of the anterior tibia became greatly exaggerated.

The question now arises, does the dropping of the water on the foot in itself, without the electrical reflex, produce this contraction? When they discontinued the electrical stimuli, there is no contraction of the anterior muscle at all. They now stop the dropping of the water and the muscle returns to its minimal contraction. Exactly this same experiment can be done with a drop of nitric acid on the cat's knee. It can be done by stroking the fur with an applicator. It can be done even by blowing strongly on the hair with a pipette. In other words, they were showing a reflex taking place through the central nervous system in a spinal cat and that when this reflex is at a minimal level, innocuous stimuli such as stroking the fur or blowing air on it or spreading the toes or dropping cold or hot water will tremendously exaggerate this simple reflex response through the agencies within the spinal cord.

HAROLD C. VORIS (Chicago, Ill.): I, too, have greatly enjoyed these very interesting and profitable papers. I have one question that I would like to ask Dr. Elder, and that is, if he has any explanation for the necessity of blocking or removing the fourth lumbar ganglion in his case?

I realize that in cases of this type, we are perhaps getting our effect as much or more by removing visceral afferent fibers as by our sympathetic denervation. Certainly, as I understand it from what we know of anatomy at the present time, there are no efferent sympathetic rami below the

second lumbar roots and, therefore, at least from the theoretical standpoint, should it be necessary to remove the fourth lumbar ganglion in order to accomplish sympathetic denervation of the foot? I would like to know if he has any explanation for the necessity of blocking the fourth lumbar ganglion in order to obtain complete relief in this case.

ANATOLE KOLODNY (closing): As to the question asked by Dr. Adams, how Dr. Pretty and I explain the discrepancy between the large volume of blood existing in such an extremity and still have the spasm, I will leave this to Dr. Pretty to answer. I just want to limit myself to two or three points raised by Dr. Gurdjian.

Dr. Gurdjian says that he thinks Dr. Buerger first pointed out that you find an inhibition in the electro-encephalogram, an inhibition after any irritation during the electro-encephalography. You see the patient opening his eyes, or you are talking to the patient or asking him questions. We always find that. But we always find it on both sides of the brain at the same time. I had correspondence with the doctor who I think is probably the most outstanding man today in electro-encephalography, Dr. Gibbs, about that question and he is of the same opinion, that any irritation of the patient at the time electro-encephalography is carried on is not always manifested by inhibition, but sometimes by acceleration of the waves, and it is equal on both sides, while the curves I showed here speak for themselves.

Of course, we doctors are individualists and we like to interpret findings as we think. It is up to the person.

I do not want to enter into any anatomic debate. In my paper, which I did not read in its entirety here, there is a question about anatomy, too. But there is one more important point I want to make, and I want to make it as a patient to doctors. I never learned so much to respect a patient's complaints as I learned during the last five weeks, when I was a patient in a hospital. I used to say that patients were hysterical, like Dr. Elder has said when he saw that boy, namely, that he was in an acute hysterical stage. I used to say it, too. I will give you an example:

I was operated upon on the left side of the chest and have an extensive thoracic scar. At the time I was in the hospital, whenever the nurse used to wash the left side of my face, I had terrific pain in the scar. She would just touch the left side of my face and I would have a pain in the scar. The same thing was true of the left arm. Now, the only rational explanation that I have is that my scar at that time irritated many blood vessels and the slightest irritation on that side, causing contraction of the capillaries and the arterioles, immediately reflected itself in exaggeration of the spasm on the

left side; and I am not a hysterical man. In thirty years of practice, I have never been sick a single day.

H. GURTH PRETTY (closing): Dr. Kolodny mentioned that he is not a hysterical individual, but he almost had me in hysterics when he said that I could answer a question that he could not.

Now, one question was brought up, that of increasing the blood volume in a limb after interruption of the sympathetic. I think, because you get an increase in temperature, that does not necessarily mean that you have an increase in blood volume. If you liken the thing to a radiator, if you increase the circulation of hot water through a radiator by means of a circulating pump, that radiator will emanate a great deal of heat. If, on the other hand, you slow up the circulation of the water through the radiator, you emanate less heat; so I do not think it is a question of increasing blood volume but it is a question of increasing blood interchange.

Then comes the question of removal of the first lumbar ganglion and also the question of removal of the fourth lumbar ganglion. That brings in many debates. I do not know how we are going to settle it. Certainly, if you do not remove the first lumbar ganglion, you do not get satisfactory results in any type of sympathetic operation. The disadvantages of removing the first, as we all know, are that it is supposed to interfere with the ejaculator mechanism. That does not seem to apply in every case, in my experience. I have many in whom it made no difference whatsoever, whereas in others, it has; so that is still a debatable question.

As to the question of removing the fourth, I will grant you that by blocking the fourth with the others, you get a good response. You will get a

good response up to two and three years after the fourth, but where the fourth has been removed, there is a tendency in these patients to revert after three or four years; in other words, the results are not as good or as lasting as those cases of removing, 1, 2, 3 and not the fourth.

Regarding the question of using tetraethylammonium chloride intravenously versus intramuscularly, there is no doubt that your effect is more lasting intramuscularly, but my point is that by using the tetraethylammonium, you are foolish to attempt to use it as a prolonged method of treatment. The only answer is, if your case requires sympathetic interruption for a long time, by all means be radical about it and do not waste time playing around with tetraethylammonium.

The other question of reducing the edema in fractures, I quite agree that if we get our fractures early and treat them immediately, we do not get edema. That is the ideal situation. But how often do we get our fractures in the big general hospital immediately? Some of them are referred from country districts, from different areas. The edema is well developed. Therefore, we have to use some ways and means of getting that edema down quickly, and your sympathetic interruption will certainly facilitate it.

The question of cordotomy is an old debatable point. I think that is a hanger-on of the neurosurgeons, and they are inclined to swing back to cordotomy. They are inclined to steal the sympathectomies from the other people. I do not believe that by doing a cordotomy after a sympathectomy, you are going to improve the condition. I think, if your condition has gone to such an extent that sympathectomy or interruption will not do it, you had better leave cordotomy alone.



# UNUNITED FRACTURE OF THE NECK OF THE FEMUR\*

## CAUSES OF FAILURE OF INTERNAL FIXATION AND TREATMENT

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THE objects of this paper are (1) to cite the pitfalls in the management of fractures of the neck of the femur which contributed to non-union, (2) to stress *prevention of the pitfalls* in order to reduce the incidence of non-union, (3) to urge the use of visual osteotomy when in attempting internal fixation some of the pitfalls seem inevitable and (4) to report our experience with twenty-six ununited fractures of the neck of the femur.

Since Kellogg Speed<sup>1</sup> delivered his oration on the "Unsolved Fracture" in 1935, the transfixion of recent fractures of the neck of the femur has been widely employed. However, the problem is still very formidable. While the immediate objectives may have been obtained, there is no assurance that the transfixion of the fracture will result in osseous union with a functioning and painless hip. Too many factors, known and unknown, play a rôle in interrupting union and in producing degenerative arthritis or aseptic necrosis. (Table 1.)

Sixteen ununited fractures of the neck of the femur are known to have occurred among the 146 which had been pinned on our service during the six years prior to January, 1947. Ten ununited fractures were admitted with no previous treatment, either because of the patient's reluctance to submit or to the physician's failure to recommend operation.

Excerpts from two reports evaluating the intermediate and ultimate results show the need for studying these unsolved clinical problems which remain a challenge to the surgeon: (1) The Fracture Committee of the American Academy of Orthopaedic Surgeons in 1941<sup>2</sup> reported that (1) non-union occurred in forty-one or 23.7 per cent of 173 cases which met the committee requirements for classification as good reduction, viz., anatomic replacement of the fragments or a slight valgus position; (2) arthritic changes were observed in the head following bony union in forty-three or 27.3 per cent of 157 cases following fixation with Smith-

Petersen nail or multiple wires. (2) Boyd and George,<sup>3</sup> in their report of the complications and results of internal fixation of 300 acute central fractures of the neck of the femur, found that nineteen or 13.5 per cent of 122 hips failed to unite, nine of these following satisfactory

TABLE I  
COMPLICATIONS OF 146 INTRACAPSULAR FRACTURES

	No.
1. Ununited fractures.....	16
2. Degenerative arthritis.....	4
3. Aseptic necrosis.....	2
4. Reinsertion of inaccurately inserted nail.....	18
5. Broken calibrated indented guide wires.....	4
6. Foreshortening of neck and extrusion of nail...	8
7. Absorption of neck and straddling neck and shaft by Smith-Petersen nail.....	5
8. Infection (6) absorption of head.....	1
9. Thrombophlebitis and pulmonary infarction (2 recovered).....	4
10. Pneumonia.....	12
11. Died.....	14

reductions and nailings. They added that aseptic necrosis and arthritic changes in the hip each occurred in 33.6 per cent and that all patients with aseptic necrosis did not have arthritic changes. From their findings they indicated that a good end result could be prognosticated in 43.6 per cent.

Compere and Wallace's<sup>4</sup> experiments on dogs indicate that the fate of the head of the femur following transcervical fracture is favorably influenced by immediate accurate reduction and internal fixation. If Phemister's<sup>5</sup> theory that the fate of the head following fracture is determined on a basis of injury to the blood supply to the head at the time of fracture, it is logical to reduce the "time lag" between fracture and reduction-fixation. Further damage to the capsular vascular tree by rotation, displacement and shearing stress will be eliminated by early transfixion.

### PITFALLS IN THE MANAGEMENT OF RECENT FRACTURES

Our experience has led us to believe that, in some instances, failure to obtain osseous union

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FIG. 1. A, Case F. W. failure to reduce and convert the vertical plane to a horizontal position; failure to transfix the fragments.

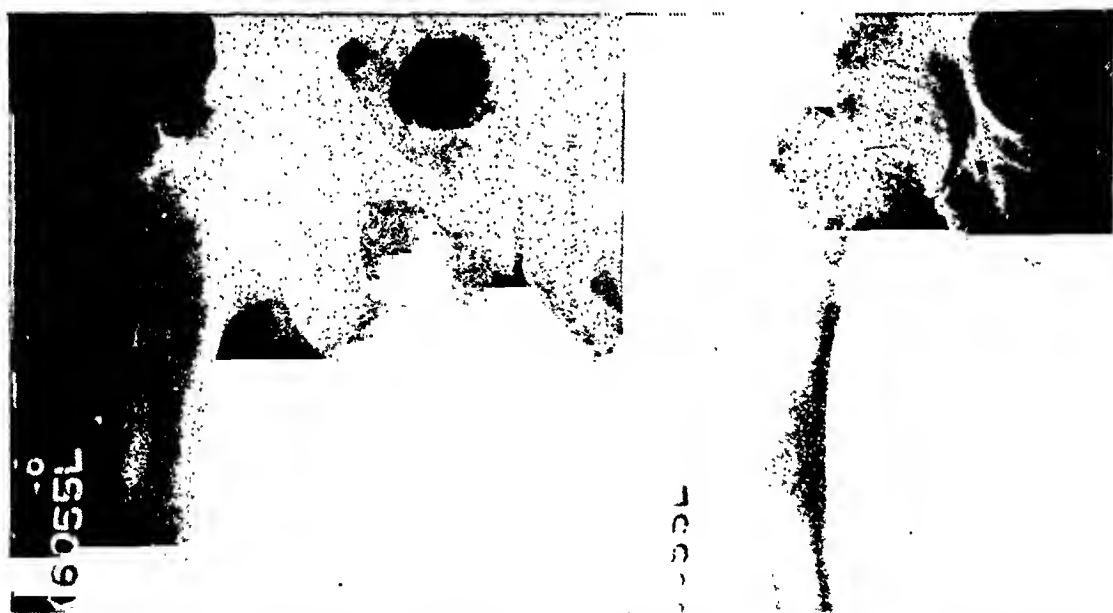


FIG. 1. B, nail removed one week later; radiographs four months after anterior McMurray osteotomy; stable and painless hip.

could have been prevented. Primarily, *operation should not be delayed*. Early reduction and transfixion is indicated to attempt to salvage and re-establish the continuity of the vascular bed. Secondly, *we have encountered many pitfalls* during reduction and transfixion which if prevented would probably have reduced the instances of non-union. These must have been common to others but repetition and emphasis may be helpful.

#### PITFALLS IN REDUCTION AND TRANSFIXION

- I. Failure to reduce the fracture completely and produce a valgus pedestal for the head
- II. Failure to engage or adequately transfix the proximal fragment (Figs. 1A and B, Case F. W.)
- III. *Medial superimposition* of the inner aspect of both fragments. This results in medial foreshortening of the neck. This may



FIG. 2. A, Case M. G. November 12, 1946, incomplete reduction, medial superimposition of fragments and external rotation of shaft. The nail transfixed both fragments on the lateral film. B, March, 1947, patient bore weight contrary to instructions; foreshortening of the neck and extrusion of base of nail.



FIG. 3. A, Case E. C. sixty years; radiograph six days after injury; failure to reduce the fracture and medial superimposition of the fragments, October 18, 1946. B, April 10, 1947, increased medial foreshortening, increased density fracture site, base of nail extruding.

- follow (1) incomplete reduction, (2) failure to maintain oblique non-serrated fragments in a corrected position or (3) tilting the proximal fragment by an oncoming nail due to failure to fix the fragments adequately by strong guide wires. (Figs. 2A and B, Case M. G., and 3A and B, Case E. C.)
- iv. *Insertion of nail in outer third of the proximal fragment.* The stress and strain causes angulatory pivoting and pressure necrosis. The nail erodes the head and emerges from the proximal fragment.
  - v. *Extracting and reinsertion of too long, too short or inaccurately inserted nail* impairs the viability of the head and head (eighteen cases)
  - vi. Inadequate engagement of the proximal fragment by too short a nail may result in the nail extruding from the proximal fragment
  - vii. Penetration of the articular surface by too long a nail causing erosion of the cartilage
  - viii. *Too early weight bearing.* This applies to the cases in which the fragments have been properly transfixied in a valgus position as well as to the inadequately engaged proximal fragment.
  - ix. *The routine transfixion of the head and acetabulum by a guide wire not infrequently directed toward the ligamentum teres, to prevent rotation of the head by the oncoming nail, should be abandoned.* This procedure may impair the circulation or damage the cartilage. The procedure should be replaced by two parallel strong non-calibrated guide wires into the head.
  - x. Calibrated indented guide wires should be avoided because the indentations impair their tensile strength. The break occurs at the site of an indentation from the impact of the oncoming nail (1) if the fragments had not been stabilized by impaction or (2) the extremity had not been rigidly immobilized on a fracture table (four cases)
  - xi. A screw should not be used to transfix the base of the Smith-Petersen nail to the shaft. If foreshortening does occur, it is obviously more desirable that the base of the nail extrude than to allow the nail to penetrate the articular surface gradually.
  - xii. *Fracture improperly selected for transfixion:* An inadequately immobilized fracture of two weeks' duration may have impaired the blood supply of the head. Considerable absorption of the neck may be present. *Osteotomy* is indicated because the absorption of the neck may be progressive even though transfixion appears satisfactory. This may result in complete absorption of the neck with: (a) the nail straddling both fragments (Figs. 4A to D, Case S. S.); (b) erosion with penetration of the nail through the head (Figs. 4A to D, Case S. S.); (c) extrusion of the nail from the shaft with foreshortening of the neck (Fig. 5A, Case E. K.)
  - xiii. Infection and circulatory disturbance leading to absorption of the head and neck (Fig. 6, Case M. L.)

#### FACTORS FOR SATISFACTORY TRANSFIXION

To enhance the successful transfixion we wish to reiterate that the following conditions are indispensable:<sup>6,7</sup> (1) Immediate reduction, (2) immobilization on a fracture table to maintain reduction and eliminate the possible change in position of the fragments during the variable duration of the operative procedure, (3) the use of two strong non-calibrated  $\frac{3}{16}$  inch guide wires inserted  $1\frac{1}{2}$  cm. apart and parallel to each other to stabilize the reduced proximal fragment; the use of the best positioned guide wire for the insertion of the properly selected cannulated Smith-Petersen nail or similar cannulated device which incorporates the principle of preventing angulation, shearing or rotation and (4) the confirmation of all three steps by good lateral and antero-posterior roentgenograms.

#### ALTERNATIVE INTRA-ARTICULAR ARTHROTOMY AND OSTEOTOMY

If the good reduction and good transfixion cannot be achieved and pitfalls seem inevitable, the fracture site should be exposed through an anterior incision and transfixion should be attempted. This is by no means a simple procedure, particularly if previous attempts have failed. It should be reserved for patients in the younger age group. While the fracture surfaces are exposed and the fragments may be hooked

into position, the operation is time consuming as it also requires radiographic control to transfix the fragments accurately with the cannulated nail. The visual realignment of the fragments on their inner anterior aspect may be misleading. There may be superimposition of the inner aspect of both fragments with a resulting poor pedestal. Failure to obtain and maintain a satisfactory position of the fragments or failure to hold and transfix the fragments requires that the surgeon decide whether or not (1) to continue further attempts at correction and transfixion, thus involving greater risk to the patient and further jeopardizing the neck and head by repeated insertions of the nail or (2) to defer the operation until another day and again attempt to reduce and accurately transfix the fragments. From our observation of unsuccessful repeated attempts we believe that a visual osteotomy should be performed at the first operation if the objectives cannot be obtained and the condition of the patient is satisfactory. Otherwise the visual osteotomy should be performed as soon as the patient has satisfactorily recovered from the first operation and the reaction of the tissues to the additional trauma had subsided, usually within ten to fourteen days. The Leadbetter cervical axial osteotomy was satisfactorily performed in five cases in the older age group in which reduction and transfixion could not be satisfactorily achieved. McMurray performed twenty-three subtrochanteric osteotomies for recent fracture and bony union followed in all.<sup>8</sup>

M. D., a female, seventy-five years old, sustained a high transcervical fracture on January 2, 1947, with considerable upward displacement and outward rotation of the shaft. The fracture was reduced and transfixed with a  $3\frac{3}{4}$  inch Smith-Petersen nail. The films on January 4th revealed the shaft and head transfixed at an angle of 125 degrees, the shaft externally rotated and some superimposition of the fragments. The films on January 20, 1947, revealed the nail extruding from the head. On January 28, 1947, a Leadbetter-McMurray-Brackett osteotomy was performed and the extremities were immobilized in plaster. In April, 1947, the cast was removed. There is osseous union and good general alignment of the fragments. (Figs. 7A to C.)

#### TREATMENT OF UNUNITED FRACTURE OF THE NECK OF THE FEMUR

In 1936, McMurray<sup>7</sup> reported twenty-seven cases of ununited fracture of the neck of the

femur treated by a bifurcation operation. This was based on the suggestion of Lorenz that the stability of the hip could be restored by bringing the support under the center of the acetabulum. Schumm,<sup>10</sup> in 1937, reported his experience with the Schanz osteotomy in a series of twenty-eight cases in which he claimed increase in stability of the hip and a definite relief from pain and fatigue. In 1940, Reich<sup>11</sup> advocated a guide wire, pin or screw in the direction of the proposed osteotomy and an anteroposterior roentgenogram to determine the exact level of osteotomy. Twenty-two of his twenty-six patients were able to get about with little difficulty or discomfort. Speed and Smith,<sup>12</sup> in 1940, obtained solid osseous union between the head and neck of the femur in fifteen of thirty cases following osteotomy and they indicated that osteotomy may be performed in preference to reconstruction.

The encouraging experience of these surgeons and the less formidable nature of the oblique osteotomies prompted us to accept the McMurray operation and to employ a guide wire to determine the desired location of the proposed osteotomy as advocated by Reich. Eight such operations were performed and the results are tabulated in Table v. The "simplicity and absence of shock" which McMurray claimed was substantiated by our experience. The procedure offered the simplest approach to restoring a normal anatomic and physiologic pedestal for the head. While our results were not uniformly satisfactory, they were encouraging in five cases in which union and stability were obtained.

Leadbetter<sup>13</sup> made an extremely valuable contribution by further simplifying the operative procedure when in 1944 he proposed an osteotomy high in the cervical axis through an anterior approach. This operation offers advantages as follows: (1) Any uncertainty as to the proper level, direction or rotation of the osteotomy is eliminated. (2) Visual inspection of the fracture site to determine the extent of absorption of the neck, the state of viability of the head, the extent and nature of the interposed tissue is possible. There is also opportunity to remove this tissue. (3) Visual mobilization of the shaft, which may have been displaced upward and be held by contracted muscles thereby sacrificing the minimum amount of length, is also possible. (4) The necessity of using a guide wire and taking re-

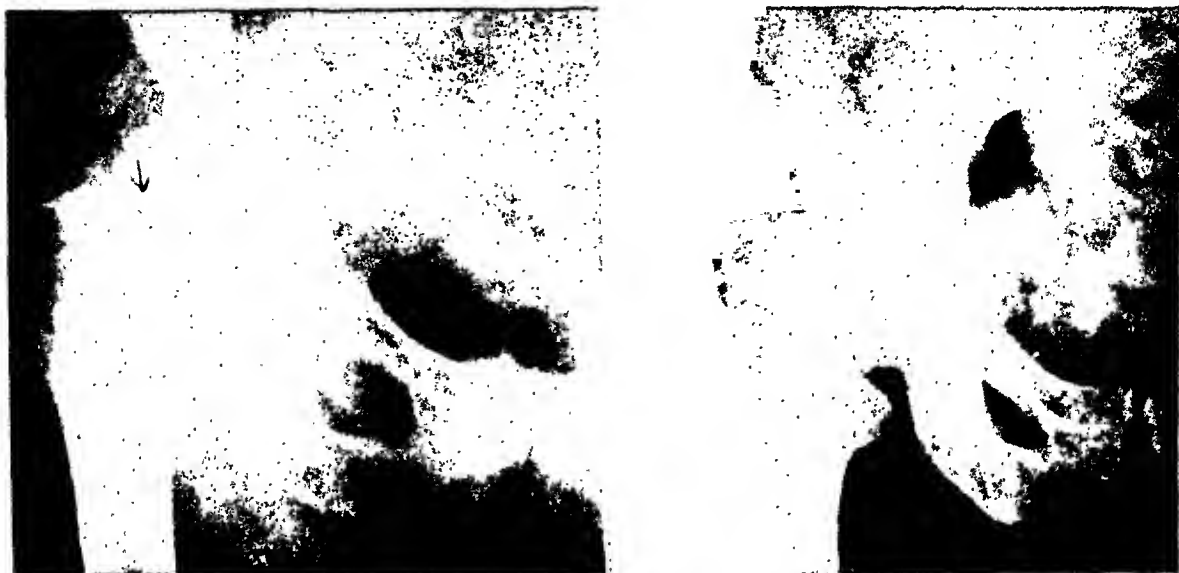


FIG. 4. A, Case S. S. sixty-nine years old. Fractured hip six weeks before admission; position of fragments December 2, 1943, some absorption of the neck.

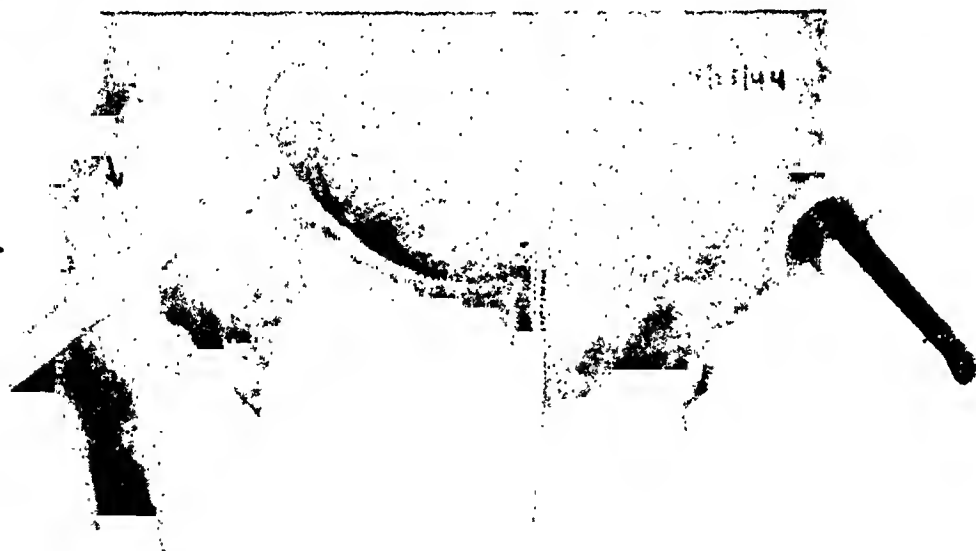


FIG. 4. B, May, 1944, progressive absorption of the neck; five months after transfexion; tip of nail encroaching closer to articular surface; no pain?

peated roentgenograms to determine the site of a guide wire or osteotome is obviated. (5) The procedure is less time-consuming and therefore less shocking to the patient. (6) A more exact anatomic and surgical approach to furthering the six criteria which Leadbetter considered ideal for repair of non-union is offered. These are: (1) preservation of the articulation of the head and acetabulum, (2) establishment of a normal acetabular thrust, (3) creation of positive pressure by a true

valgus, (4) allowance for contact of cancellous bone surfaces, (5) preservation of adequate circulation and (6) production of minimal shortening.

In April, 1944, Rowe and Ghormley<sup>14</sup> reported that thirty-four Brackett operations had been performed at the Mayo Clinic and that good results were obtained in twenty-three or 67.7 per cent of the cases. They also reported good results in ten of eleven cases which they internally fixed with a Vitallium screw driven



FIG. 4. C, October, 1946, nail beyond articular surface; patient has been getting about on crutches; had pain: four weeks.



FIG. 4. D, February, 1947, three months after combined operation; films taken in abduction and adduction; in May, 1947, no pain, firm union.

through the transplanted trochanter and the shaft into the head fragment.

The most frequent cause of failure which we have encountered in both the intra-articular and extra-articular osteotomies was slipping of the shaft. Weekly radiographic examinations were made while in plaster to detect the slightest change in the position of the shaft. In two cases the loss was detected during the first week after the operation and in both cases wedging of the plaster spica restored the shaft to position. Other observers reported slipping of the shaft as the most frequent cause of failure following McMurray or Schanz osteotomies. Rowe and

Ghormley<sup>14</sup> and Magnuson<sup>15</sup> reported that the most frequent cause of failure with the Brackett operation was slipping of the shaft.

#### McMURRAY—LEADBETTER—BRACKETT PROCEDURE

In eleven patients the anterior incision was employed. In four the Leadbetter cervical axial osteotomy was performed. In seven we combined the McMurray, Leadbetter osteotomy with a partial Brackett procedure by scooping out the inner component of the head and implanting the rounded or squared inner component of the osteomotized shaft into the



FIG. 5. A, Case E. K. Smith-Petersen nail inserted February 3, 1944, fifteen days after fracture; films taken in abduction and adduction three years later, March, 1947; absorption of the neck; nail pivoting on head; increased density of shaft, nail extruding and foreshortening of the neck; pain, shortening and no stability.



FIG. 5. B, combined operation March, 1947, plaster spica three months; films July, 1947, corrected position maintained; no pain.

partially scooped out proximal fragment. The pointed inner portion of the sectioned greater trochanter is wedged between the under outer surface of the head and the shaft (1) to augment the blood supply to the head and (2) to prevent rotation of the head and outward displacement of the shaft. (Figs. 8 A, B and C.)

The muscular attachments of the greater tro-



FIG. 6. Case M. L. The patient, sixty years old, sustained subcapital fracture April 26, 1943; admitted May 13th; Smith-Petersen nail inserted May 14th; nail extruded from the head; reinserted June 1st, infection with drainage for many months. The nail was removed November 15, 1943. Gradual absorption of head and neck took place. Film May, 1945, revealed base of neck fused to outer rim of acetabulum.

chanter are sutured to the muscles of the distal fragment. We have not transfixed the fragments with a screw as advocated by Rowe



and Ghormley. The double spica does not include the ankle. It is believed that some absorption takes place during the first and second week at the sight of implantation of the head and shaft. By omitting the plaster from the foot, sustained impaction of the head and shaft is not

thirty-eight years old and the oldest seventy. One patient died. The result was fair in one and poor in the two others. However, one patient whose fibular graft broke and the nail extruded three months after the operation was again operated by the McMurray extra-articu-

TABLE II  
SUMMARY

	Operations	Shaft Slipped		Result			
		Entirely	Partially	Good	Fair	Poor	Died
Bone graft and Smith-Petersen nail.....	4	..	..	..	1	2*	1
Whitman reconstruction.....	3	..	3	..	2	1	
McMurray-Lorenz extra-articular osteotomy.....	8	2	2	3	2	2	1
Intra-articular osteotomy, Leadbetter-McMurray..	4	..	2	2	1	1	
Leadbetter-McMurray-Brackett.....	7	1	3	4	1	1	1
	26	3	10	9	7	7	3

\* One patient subsequently had an extra-articular osteotomy with satisfactory result.

impeded. Leadbetter bivalved his casts in four weeks and removed them in eight weeks. We have continued immobilization in plaster eight to fourteen weeks believing that the pain and discomfort in the thigh is less and that osseous union may be more stable. To date there has been no untoward effects from immobilization in plaster.

**Results.** There were twenty-six operations on twenty-four patients. Of the twenty-four patients, seventeen were females and seven were males. The average age at the time of operation was sixty-five years; the youngest was thirty-eight years and the oldest eighty-seven. The average period of non-union was sixteen months, the shortest was two months and the longest was nine years. (Table II.)

**Fifteen patients had previous operations.** In twelve the Smith-Petersen nail gradually extruded from the head either from angulatory pivoting or necrosis of the head or the nail had not adequately engaged the proximal fragment. In three cases the nail straddled the head and shaft with progressive absorption of neck. Nine patients had no previous operation; one had two ununited fractures.

The results of four cases treated by bone graft and Smith-Petersen nail are shown in Table III. The average duration of non-union was nine months, the shortest two and the oldest fourteen months. The youngest was

lar procedure which resulted in a satisfactory stable and painless hip. His case is also included in Table V.

Results of three cases treated by Whitman reconstruction are shown in Table IV. The duration of non-union was three, two and nine months and their ages sixty-nine, sixty-seven and sixty-three years, respectively. The results in two were fair and in the other poor. There was partial to gradual complete extrusion of the shaft, pain and lack of stability.

Results of nineteen hips that were osteotomized for non-union are as follows: The average duration of non-union was nineteen months, the shortest was three months and the longest nine years. Two of the patients died; one with Parkinsonian disease died on the seventeenth day after a McMurray extra-articular osteotomy from a coronary occlusion. The other, R. K., sixty-eight years old, was in poor condition at the time of admission. Her operation was deferred until several transfusions helped to improve her condition. The fragments slipped and she never rallied sufficiently after the Leadbetter-Brackett operation to permit wedging of her cast. She died four weeks after the operation.

Two of the seven who survived the extra-articular osteotomies had poor results while five had osseous union and fairly stable, painless hips. (Table V.)



FIG. 7. A, Case M. D. seventy-five years old, fracture transfixed January 2, 1947, the day of admission; films reveal the shaft externally rotated and superimposition of rotated fragments.

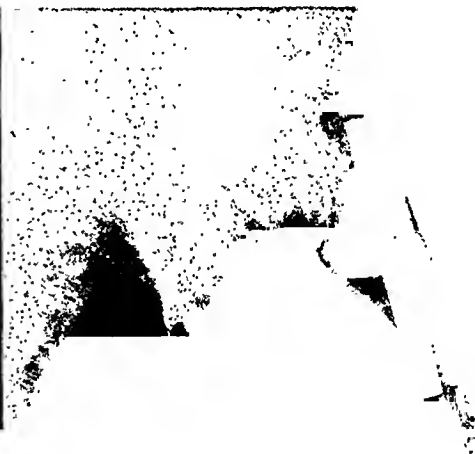


FIG. 7. B, eighteen days later nail has extruded out of head.

Of the ten patients who survived the intra-articular osteotomies, four had McMurray procedures according to the technic advocated by Leadbetter. Two of these had satisfactory results. The result is fair in one and poor in the other because the shaft slipped although there is some stability in both. (Table VI.)

In four of the seven intra-articular osteotomies, in which the Leadbetter-McMurray-Brackett principles were applied, the results are satisfactory. One patient, seventy-five years old, who had an unsuccessful Lorenz osteotomy in another institution, was again operated upon one year later. There was complete absorption of the neck and marked upward displacement of the shaft. A satisfactory position was maintained for ten weeks with the aid of a hook

incorporated in plaster. Films taken without plaster in abduction and adduction revealed the shaft pivoting on the head. This we attributed to too oblique an osteotomy and insufficient bony contact. Films eight months later reveal some new bone but the shaft still pivoted on the head. (Figs. 10A, B and C, Case F. H.) One patient died; another was operated upon too recently to evaluate.

There was some stability even in the presence of a shaft that slipped from under the head after the osteotomy in practically every case. In Case A. P., who had both a three months and a nine year old ununited hip, the shaft slipped following the osteotomy on the three months old ununited hip; the shaft rested under the rim of the acetabulum and the patient walked

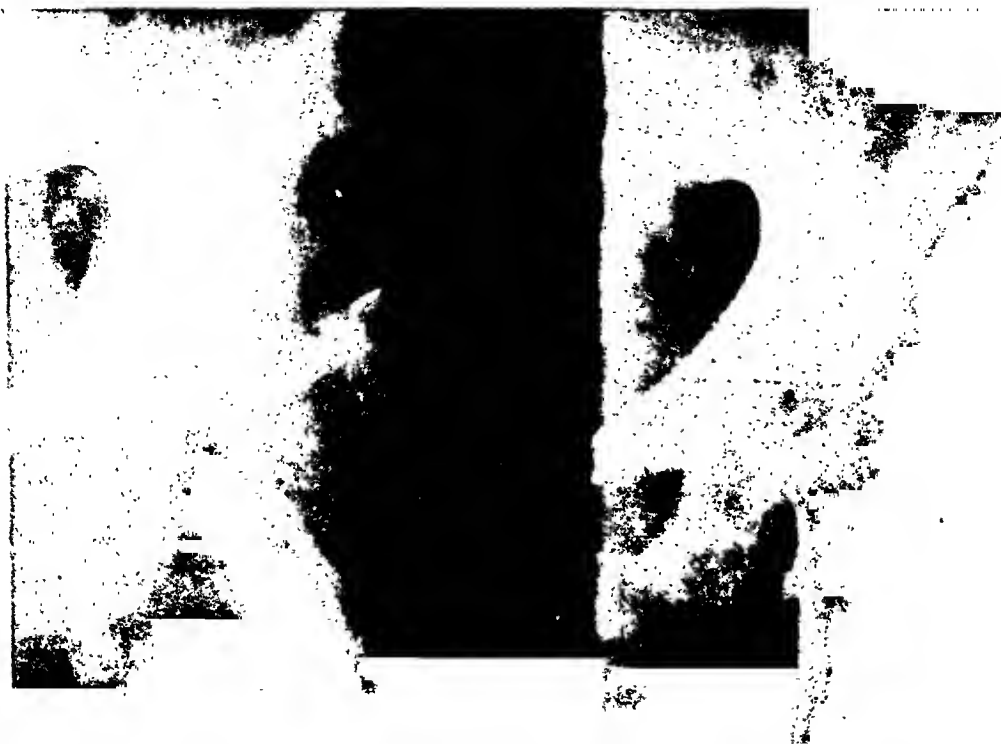


FIG. 7. C, combined osteotomy performed January 28, 1947; spica cast for three months, films in abduction and adduction April, 1947, firm union, no pain, good weight-bearing hip.

without pain and bore weight with the aid of crutches. (Figs. 9A, B and C.)

Four cases deserve reporting because each presented different findings:

#### CASE REPORTS

CASE G. M., eighty-seven years of age, in excellent physical condition, sustained her fracture in June, 1945. She was admitted with complete absorption of the neck and a viable head. In December, 1946, a combined osteotomy and then ten

weeks in plaster resulted in a united fracture and a stable and painless hip. In May, 1947, there was no pain and the patient is very active. This is our best result. (Figs. 11A and B.)

CASE A. P., a fifty-nine year old woman, sustained a fracture of her right hip in March, 1946. She was admitted in July. In August, a Leadbetter-McMurray operation was performed. The shaft slipped. The patient also had an ununited fracture of the left hip which she sustained nine years ago. She lived on a barge for the nine years. Radiographic examination revealed complete absorption

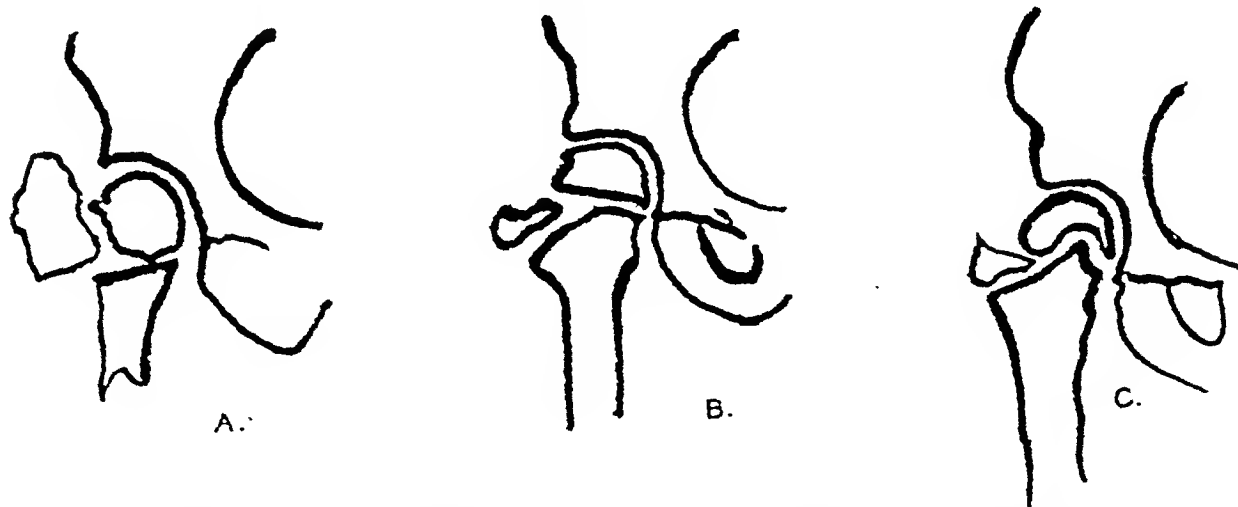


FIG. 8. A, after T. P. McMurray (*J. Bone & Joint Surg.*, 18: 319, 1936). Line of section of modified Lorenz osteotomy and displacement of lower fragments; B, after Leadbetter, G. W. (Cervical-axial osteotomy of the femur. *J. Bone & Joint Surg.*, 26: 714, 1944). Position of the fragments following visual osteotomy. C, combined McMurray-Leadbetter-Brackett procedure; scooping out the inner half of the head and implanting the osteotomized shaft and wedging the sectioned trochanter between the fragments.

TABLE III  
FOUR CASES OF UNUNITED FRACTURES OF THE NECK OF THE FEMUR TREATED BY A BONE GRAFT  
AND SMITH-PETERSEN NAIL

Case	Age	Date of Fracture	Previous History	Date of Operation	Operative Findings	Postoperative Course	Result
W. C.	70	Jan. 1941	Russel traction in another hospital	Sept. 1941	Viable head; partial absorption of neck	3 months later nail extruded; 3 months later fibula graft fractured	Poor; non-union neck; some new bone
M. C.	55	Aug. 1942	No treatment	Oct. 1942	Partial absorption of neck—head viable	Infection Welchi subcutis; nail removed 5 months later; one month later coronary infarction	Died
A. K.	54	April 1942	No	Aug. 1942	Questionable viability of head—partial absorption of neck	3 months later fibula graft broke and nail extruded; osteotomy (McMurray) Nov. 1942, cast	Satisfactory stable painless hip after osteotomy
R. Mc	38	Sept. 1941	Snapped hip on telephone pole; SPN* inserted after 2nd attempt	Nov. 1942	Nail bridging gap 1½ inches between head and shaft	3 months later graft broke in spica nail removed Jan. 1945, exuberant new bone	Fair; partial subluxation of head; exuberant new bone; hip not stable

\* SPN = Smith-Petersen nail.

TABLE IV  
THREE CASES OF UNUNITED FRACTURES OF THE NECK OF THE FEMUR  
TREATED BY WHITMAN RECONSTRUCTION

Case	Age	Date of Fracture	History	Date of Operation	Operative Findings	Cast	Shaft out of Acetabulum	Course	Result
B. C.	69	Dec. 1942	SPN* in another hospital; extruded	March, 1943	Some absorption of neck; viability of head questionable	6 wk.	30-40%	July, 1944 Fr. of shaft; shaft partially extruded	Fair ?
L. G.	67	Dec. 1941 ?	Traction	Jan. 1942	Absorption of entire neck; head viability questionable	6 wk.	20% + ?	Stability ?	Fair ?
G. S.	63	July, 1945	SPN* 4 wk. after fracture; nail extruded	Apr. 1946	Absorption of neck; viability of head impaired	2 mo.	50% +	Shaft gradually extruded; pain	Poor

\* SPN = Smith-Petersen nail.

of the neck and increased density of the distal third of the head. In October, 1946 the combined Leadbetter-McMurray-Brackett operation was performed. Most of the marble white bloodless distal inner two-thirds of the head was scooped out. A bone hook encircling the shaft was utilized to

straddling both fragments. In December, 1946, the nail had eroded the head. A Leadbetter-McMurray-Brackett operation was performed and a spica was applied for three months. In May, 1947, union was firm in abduction and adduction. The hip was stable and she had no pain. (Figs. 4A to D.)

TABLE V  
EIGHT CASES OF UNUNITED FRACTURES OF THE NECK OF THE FEMUR  
TREATED BY EXTRA-ARTICULAR OSTEOTOMY

Case	Age	Date of Fracture	History	Date of Operation	Operative Findings	Cast	Shaft Slipped	Postoperative Course	Result
P. B.	53	June, 1944	SPN*—in another hosp., nail extruded decubitus ulcer	Dec. 1944	Viable head; some absorption of neck	3 mo.	50%	7 mo. later 2 screws fixed trochanter to pelvis	Fair; 3 yr. with cane
B. C.	46	Mar. 1944	SPN* 3/21/44 walked; nail extruded	April, 1945	Viable head; absorption of neck	3 mo.	40%	Dec. 1945, fracture of other hip	Satisfactory; 16 mo. walks with cane
R. H.	74	Jan. 1943	SPN*—4 mo. later nail extruded	May, 1944	Head viable; absorption of neck	3 mo.	No	Uneventful	Satisfactory; stable; painless
F. I.	60	Nov. 1944	SPN*—Parkinson; pin gradually extruded	May, 1945	Head viable; some absorption neck	+	....	17th day heart attack	Died
T. M.†	61	Oct. 1941	SPN*—nail straddling fragments	Dec. 1943	Absorption of neck; head viable	M. B. +	No	Blade did not engage head satisfactorily	Poor; non-union
B. R.	78	Oct. 1944	SPN*—nail extruded	Jan. 1945	Absorption of part of neck; head viable	3 mo.	No	Uneventful; followed 6 mo.	Fair; union
E. W.	70	June, 1945	SPN* extruded	Oct. 1945	Absorption of neck; head viable	2 mo.	80%+	Fr. ankle; fr. femur lower end; can raise heel	Poor
A. K.‡	54	April, 1942	SPN* and fibula graft (S) 1942 graft broke, nail extruded	Aug. 1942	Questionable viability of head; partial absorption	2 mo.	No	Stable; painless	Satisfactory

\* SPN = Smith-Petersen nail.

† T. M.—Moore Blount Blade Plate.

‡ A. K.—Also listed on Table treated by SPN and graft.

maintain the shaft in position and incorporated in plaster. The cast was removed after three months. Union of the left hip is firm as indicated radiographically in the abducted and adducted position. The head of the left femur, however, is dense. She left the hospital in May, 1947; both hips were stable and she had no pain. (Figs. 9A, B and C.)

CASE S. S., a sixty-nine year old female, sustained a fractured hip six weeks before admission to Bellevue Hospital in November, 1943. A Smith Petersen nail transfixated both fragments. The neck continued to absorb and soon the nail was found

CASE E. K., a forty-two year old female, sustained a subcapital fracture on January 18, 1944. She was transferred from another hospital. On February 3rd, a Smith-Petersen nail was inserted. The subsequent film revealed the angle of the shaft and head transfixated at 130 degrees with 80 per cent apposition of the fractured surfaces on the anteroposterior view and 60 to 70 per cent on the lateral. She was not seen for three years at which time the films suggested some collapse, irregularity of the articular surface, questionable increase in the density of the head and some foreshortening

of the neck pivoting around the nail when the thigh was abducted and adducted. On March 25, 1947, operation revealed the shaft displaced backward and upward and the head pivoting on the nail. There was considerable dense granulation tissue between the fragments but the head was

viable. After removal of the nail and scooping out of the inner third of the head, the osteotomized shaft was implanted into the inner aspect of the head. The greater trochanter was imbedded between the shaft and outer half of the head, sutured into position and a double plaster spica was applied.

TABLE VI  
TEN CASES OF UNUNITED FRACTURES OF THE NECK OF THE FEMUR  
TREATED BY INTRA-ARTICULAR OSTEOTOMY

Case	Age	Date of Fracture	History	Date of Operation	Operative Findings	Lead-better Mc-Murray	Lead-better Brackett	Cast	Shaft Slipped	Postoperative Course	Result
P. F.	69	1937	Treated in plaster in 1937; 8 mo.	Sept. 1942	Absorption neck; head viable	*	....	2 mo.	No	Firm union	Satisfactory
G. M.	87	June, 1945	Treated with traction in another hospital	Dec. 1946	Absorption neck; head viable	.	*	10 wk.	No	Slight knock knee; firm union	Satisfactory
F. H.	75	Nov. 1945	Lorenz osteotomy Dec. 1945, in another hospital	Oct. 1946	Absorption neck; head viable	.	* and hook	3 mo.	10%+	Knock knee some union	Poor
R. K.	68	Mar. 1945	Traction in another hospital	Dec. 1946	Absorption neck; head viable	..	*	*	100%	Poor general died 4 wk. later	Died
M. P.	70	Aug. 1946	Cast 8 wk. in another hospital	Dec. 1946	Absorption neck; head viable?	.	*	3 mo.	30%+	Firm union	Satisfactory
A. P.	59	Mar. 1946	Fell on barge; fr. rt hip—4 mo., no treatment	Aug. 1946	Absorption neck; head viable	*	....	2 mo.	80%+	.....	Fair
A. P.	59	1937	Fell on barge 9 yr. ago; left; no treatment	Oct. 1946	Absorption neck; part of head avascular	..	* and hook	3 mo.	No	Firm union	Satisfactory
S. S.	69	Nov. 1943	Fr. 6 wk. SPN;* gradual absorption neck; nail straddling fragments	Dec. 1946	Absorption neck; necrosis head at site of nail; nail straddling fragments	..	*	3 mo.	20%—30%	Firm union	Satisfactory
V. T.	75	May, 1946	SPN* early weight bearing; eroded and extruded	Aug. 1946	Absorption neck; head viable	*	....	3 mo.	40%+	Pain; lack of stability	Poor
M. T.	66	Nov. 1944	SPN* extruded; reinserted; extruded	April, 1946	Absorption neck; head viable	*	....	3 mo.	No	Firm union	Satisfactory
E. K.	42	Jan. 18, 1944	SPN*—2/3/44; non-union	March, 1947	Absorption neck; head viable	..	*	3 mo.	No	.....	?

\* SPN = Smith-Petersen nail.



Fig. 6. A. C. A. H. Intersegmental movement in state of left hip flexion, rotation and orientation in state of the right leg of nine-year-old female, exposed to a stress of 1.14 of load and increased density of external elements to a maximum of displacement of shaft,  $\alpha$ ,  $\beta$  and  $\gamma$  degrees,  $\alpha$ ,  $\beta$ ,  $\gamma$  load, to maintain of left hip position in hip joint and on the plane of  $\alpha$ ,  $\beta$ ,  $\gamma$  degrees, after a full rotation of left hip, and by them on density of the remaining part of load,  $\alpha$  - going to the leg.



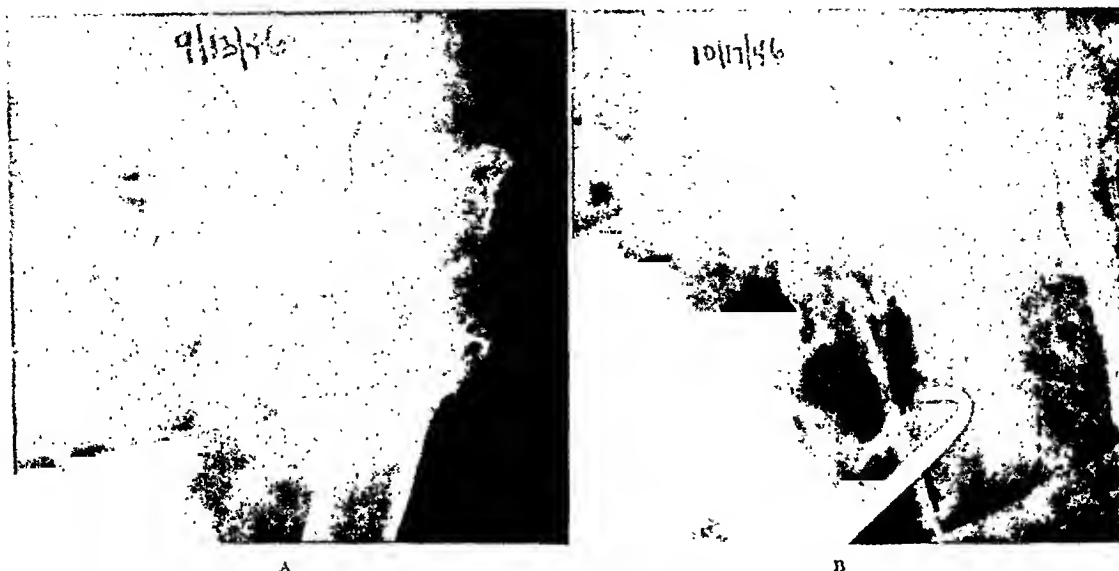


FIG. 10. A, Case F. H. seventy-five years old, sustained fracture in November, 1945; Lorenz osteotomy in December, 1945, in another institution; admitted to Bellevue Hospital September, 1946. Complete absorption of the neck and marked upward displacement of the shaft. B, October 8, 1946, anterior combined operation with hook incorporated in plaster to prevent outward displacement of shaft.



FIG. 10. C, December 23, 1946, after ten weeks in plaster, showing shaft pivoting in abduction and adduction; in June, 1947, more new bone, shaft still pivots, some stability present.

The subsequent films every two or three weeks revealed that position of the fragments has been maintained. (Figs. 5A and B.)

#### SUMMARY AND CONCLUSIONS

Pitfalls in reduction and internal transfixion accounted for sixteen ununited fractures in 146 acute fractures of the neck of the femur. Ten other ununited fractures had no treatment.

The high incidence of non-union can be largely prevented or at least materially reduced by early and accurate reduction and transfixion.

By eliminating the pitfalls in the procedure one can salvage some of the blood supply of the disrupted capsule, limit and prevent shearing, rotation and angulatory pivoting.

If the objectives of proper transfixion cannot be achieved and an unsatisfactory result seems inevitable, a visual osteotomy is indicated.

Of twenty-six ununited fractures of the neck of the femur, four were treated with a bone graft and Smith-Petersen nail, three by a Whitman reconstruction operation and nineteen by oblique osteotomies, of which eight



FIG. 11. A, Case G. M. eighty-seven years old, sustained fracture in June, 1945; admitted in December, 1946; absorption of neck and upward displacement of shaft.



FIG. 11. B, combined operation December, 1946, ten weeks in plaster; films in abduction and adduction; in May, 1947, pushed walker around; no pain; slight valgus at the knee.

were by the extra-articular and eleven by the intra-articular approach.

The anterior cervical-axial osteotomy, as advocated by Leadbetter, offers a more accurate, less time-consuming procedure in carrying out the Lorenz-McMurray principles.

To obtain the overall objective of maintaining the osteotomized shaft under the head until osseous union was complete we employed the Leadbetter-McMurray principles with a partial Brackett procedure.

The period of observation of the osteotom-

ized hips is too short to evaluate the ultimate results. The immediate results in some of the cases are gratifying. It is nevertheless our thesis that the prevention of non-union should be the underlying objective in the treatment of the ununited fracture of the neck of the femur.

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# TECHNIC OF HIGH SUBTROCHANTERIC OSTEOTOMY

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THE increasing use of osteotomy in both old and fresh fractures of the neck of the femur makes it necessary to perfect a better method of performing this important procedure. The technic of the operation is usually dismissed with the statement that a high osteotomy was performed, followed by inward displacement of the shaft of the femur. Through a study of the factors causing several poor results as well as the observation of two particularly successful cases (resulting from accidental variations in the usual method of performing the operation), an improved technic has now been evolved. It is hoped that further application and study of this method will make it more useful in both old and fresh fractures of the neck of the femur. Recent communication with thirty leading fracture men as well as a study of the literature prove that we must again take stock of intracapsular hip fractures.

We all agree that pinning has been a wonderful advance. Leaving out those cases, irretrievable by any method, the percentage of good results as reported varies from 40 to 80 per cent depending on the length of time followed. Clinics located in rural areas had better results (Mayo Clinic 75 per cent) than big city charity hospitals. Vigorous old farm folk do better than ill fed slum derelicts. There is also still a wide divergence of opinion as to the best methods of pinning. By any method of internal fixation the usual causes of bad results are well known. (1) Inadequate reduction and pinning; (2) degenerated bony structure which in the aged will not support internal fixation; (3) late aseptic necrosis (or fragmentation) of the head of the femur; (4) degenerative arthritis with or without bony union and (5) too early weight-bearing on a bad mechanical line subject to shearing force.

Whatever the cause, all surgeons queried had seen a lot of bad results in cases of intracapsular fracture of the neck of the femur. Practically all stated they used some form of reconstruction operation, usually the Colonna or Brackett types, at least in the younger or more vigorous subjects, reserving osteotomy for the older group. This personal survey as well as the

literature of the past few years shows an increasing number of the leading surgeons of England and America using osteotomy for all old hip fractures with bad results whether due to mal-union, non-union or degenerative arthritis. Frank Dickson,<sup>1</sup> Leadbetter,<sup>2</sup> Wallace Cole,<sup>3</sup> Kellogg Speed,<sup>4</sup> J. S. Speed (Memphis),<sup>5</sup> George Bennett,<sup>6</sup> Hermann,<sup>7</sup> Barney Owen,<sup>8</sup> McMurray<sup>12</sup> of England, Reich<sup>9</sup> and Magnuson<sup>10</sup> are a few who now are using osteotomy as the treatment of choice in old ununited cases. Cole and Murphy<sup>11</sup> have used this method instead of primary pinning while McMurray uses it exclusively in both fresh and old intracapsular fractures. A few, though not the majority, report the use of pins to hold the fragments after osteotomy. High osteotomy is more popular because of the greater chance of bony union in the original fracture, and because internal fixation of the fragments is almost obligatory with the Schanz or low osteotomy.

It is generally conceded that the well known reconstruction operations of the hip were great contributions. Diagrammatically, all can be made to look simple and efficient. In actual practice, others as well as myself have found it necessary to use these procedures only in selected cases because of conditions present at the site of fracture or because of the condition of the patient. Such procedures as the bone-peg operation or the Brackett, Whitman, or Colonna reconstructions are all formidable as to risk and difficult of execution. J. S. Speed stated that only about 60 per cent fairly good results are obtained by these large procedures even in selected cases and that 25 per cent of the favorable results are later vitiated by degenerative arthritis causing painful and restricted hip movement. Against the net 45 per cent satisfactory results from reconstruction operations used only on good risks, most men report about 80 per cent good results with osteotomy used on all types of patients and bony union was achieved in more than half of them. The only procedure showing comparable results is the rarely indicated bone-peg operation.

Advantages of osteotomy are: (1) A simple procedure suitable to practically all age groups; (2) aseptic necrosis of the head of the femur and degenerative arthritis have not been contraindications; (3) a good weight bearing line without shearing force with or without bony union is achieved. Properly executed, a strong stable hip is the probable result in the average patient; (4) revascularization of the head of the femur which has already undergone partial aseptic necrosis is not unusual; (5) about 80 per cent good results can be expected with at least 50 per cent obtaining bony union. With proper technic the percentage of bony union can be improved; (6) few late degenerative changes have been noted following successful osteotomy; (7) normal leverage of the gluteal and psoas muscles is preserved, making for stability of the hip; (8) osteotomy is useful in treatment of malum coxae senilis; (9) the period of immobilization and non-weight bearing is short. Objections to the spica cast are minimized by active muscular exercises and proper general management while the patient is in the cast. Henderson still uses a spica cast after internal fixation of fresh fractures. The author agrees with Dickson, Henderson and others, who believe that the disadvantages of casts are overrated. The rigid, twisted, hyperextended leg in the Whitman cast often causes stiffness of joints and muscular atrophy. After osteotomy the leg is in the neutral position with the knee slightly bent and the cast is worn for only eight weeks. (10) The successful universal use of any method requires: (a) that it be simple and fool-proof in the hands of the average surgeon; (b) that gadgets and hardware be avoided as far as possible. (c) that there be a minimum of possible complications and (d) that uniformly good end results be obtained in the least time.

Osteotomy is a shorter operation and easier to perform correctly than pinning. No gadgets or internal fixation are necessary and there are fewer late degenerative changes to be expected. Only after a thorough trial in fresh cases, using a better technic, can we decide whether osteotomy is the treatment of choice. There seems no doubt that this method is best for the bad results following unsuccessful pinning. The author's method of performing this operation was worked out on old cases but recently has been used on four fresh fractures. Since the present method of performing osteotomy has been used, no instance of spreading or upward

displacement of fragments, troublesome in earlier cases, has been encountered and so far bony union has been obtained in almost all cases.

#### AUTHOR'S TECHNIC OF OSTEOTOMY

Before operation and after the usual reduction of the fracture, films are made on the operating table with the leg under manual traction. The line of osteotomy is then determined. A point as near as possible to the base of the greater trochanter is selected which will allow the line of osteotomy to go very slightly upward and inward to a level through or above the lesser trochanter. The high osteotomy keeps intact the upward pull of the muscles attached to the lesser trochanter, aiding in stability and relation of the position of the fragments. The higher the osteotomy line can be made, the broader the base of the cancellous bone that can be obtained and the better the rotation of the head. Thus more of the old fracture line can be freshened and brought into contact with the lower osteotomy fragment. To prevent knock knee, a certain amount of obliquity in the osteotomy is necessary to allow about 20 degrees abduction and still have contact of the shaft with all three fragments. The greater the obliquity of the osteotomy, the more abduction required for solid contact. Since no more than 20 degrees abduction is desirable, the direction of the osteotomy must be carefully guided so that the point of emergence is only slightly higher than the point of entry. The high osteotomy with a certain amount of obliquity provides a broad base of cancellous, very highly osteogenetic bone at the upper end of the shaft. Proof of the reparative quality of bone in this area is shown by the fact that non-union of intertrochanteric fractures is unknown.

Before osteotomy is done, the periosteum must be stripped from the whole circumference of the upper end of the shaft through a vertical incision below the greater trochanter. The periosteum should be stripped clear for 3 or 4 inches down on the shaft and as high as possible toward the trochanter and neck. The sheet of periosteum must be kept intact anteriorly and posteriorly. This maneuver is one of the critical points in performing successful osteotomy because after the bone is cut through and the shaft displaced inwardly, the periosteal connections between the shaft and the severed trochanter

insure that the greater trochanter is drawn snugly against the head and better contact against the shaft and greater trochanter is maintained. The three fragments can now be manually impacted in the desired position without fear that the fragments will spread apart. Union is more assured and internal fixation by pins to prevent separation of fragments is obviated. After separating and retracting the periosteum anteriorly and posteriorly, osteotomy is performed on the predetermined line, using an osteotome no wider than the shaft. The osteotome cuts through the periosteum on the medial aspect. At times it may be difficult to preserve both the anterior and posterior periosteal strips but any retained connection is valuable. An attempt is made to rotate the head of the femur with a blunt elevator so that the old fractured surface faces as much downward as possible. The fractured surface of the head can now be freshened by a small chisel. The shaft is displaced inward, using the osteotome as a combination lever and shoe horn. Often the upper inner point of the shaft impinging against the lower edge of the head of the femur can be made to aid in further rotating the head so that more of the old fracture line can be brought into contact with the shaft. In this way union is more apt to be obtained, more new bone is deposited in the line of weight-bearing, and the head is in a better position to receive weight-bearing should bony union not be achieved. In other words, complete valgus is obtained and the shearing angle between the head and neck of the femur is obliterated. The portion of the head lying directly above the displaced shaft and as much of its old fractured surface as possible is now further freshened with the osteotome and pieces of bone from the osteotomized margins of the trochanter and shaft are forced into or around the old fracture area. Before closure of the wound, a check up film is made to be sure the shaft has been displaced sufficiently inward and impacted solidly against the underneath margin of the rotated head.

A double pica cast to the toes of the affected leg and the knees of the good leg is applied. The body portion of the cast need only embrace the pelvic region and can be cut down in front to a point below the level of the navel. After soreness from the operation has subsided, the patient is taught to contract actively all

muscle groups systematically, exercising five minutes of each waking hour. At the end of six weeks the cast is bivalved and more vigorous exercises permitted. The entire cast is removed at the end of eight weeks and after a few more days of bed exercises, the patient is

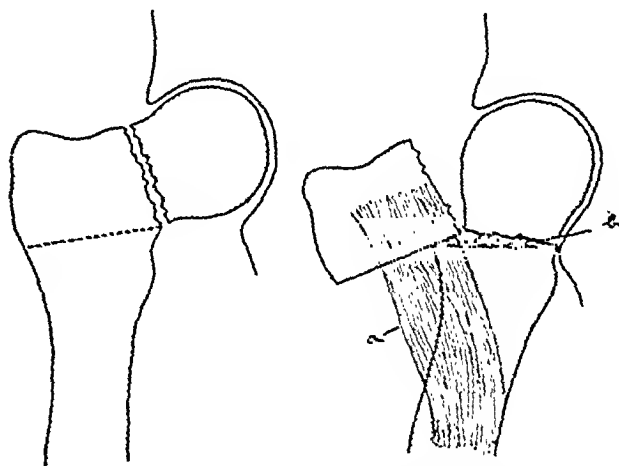


FIG. 1. Diagrams of the author's osteotomy showing a, retained periosteal connection between greater trochanter and shaft; b, bone fragments and rotation of the head of the femur.

started in a walker or on crutches with gradually increasing weight-bearing. From this point progress will vary with each case but all are encouraged to abandon walking aides as soon as possible.

#### USE OF OSTEOTOMY IN FRESH FRACTURES

Since McMurray's report about ten years ago, several men have begun to use osteotomy for fresh fractures of the neck of the femur. Murphy has reported ten cases and Wallace Cole states the method should be conceded a greater place in the treatment of this fracture. Whether we shall abandon internal fixation in favor of this procedure will require more experience. The greater danger of infection and fragmentation of the head as well as the longer period of non-weight-bearing and higher percentage of degenerative arthritis are factors arguing against internal fixation.

Points in favor of osteotomy are: (1) Complete valgus position and elimination of the shearing angle is achieved, with only about one half shortening of the leg; (2) better vascularization of the head and less danger of late arthritis and aseptic necrosis can be expected; (3) osteotomy is technically easier in fresh fractures than in old cases because the shaft can be displaced inward and the head rotated more easily. Performed by the technic previ-

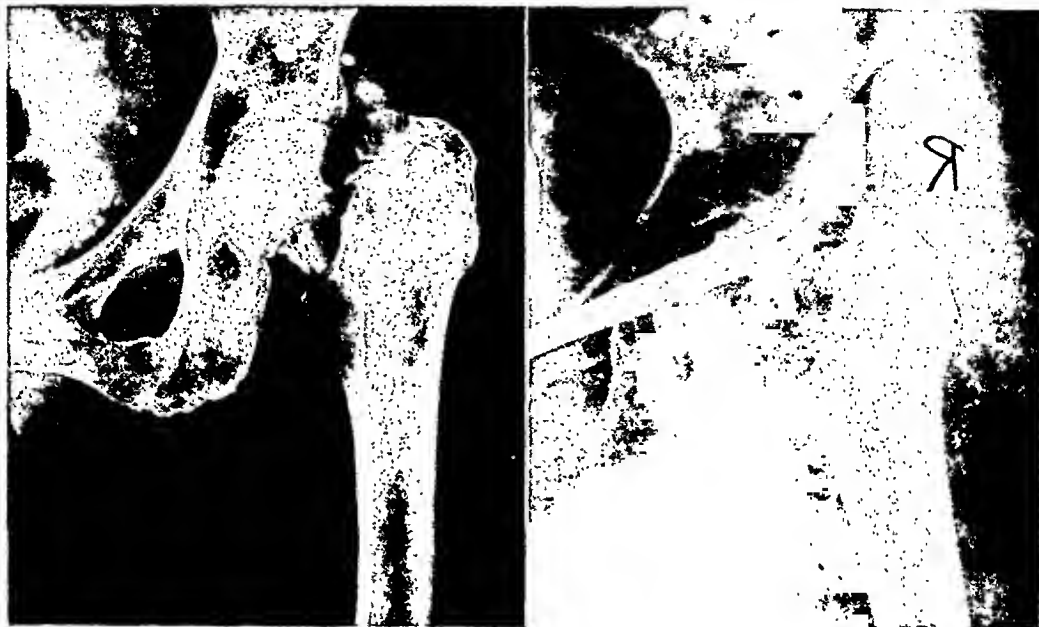


FIG. 2. A, fresh fracture of the neck of the femur; B, fracture reduced.



FIG. 2. C, completed osteotomy.

ously described, the continuity of periosteum and the pull of the common muscles attached to the osteotomized fragments tends to produce snug apposition of all three fragments without internal fixation. (4) The results so far reported have been good. The average shortening has been about  $\frac{1}{2}$  inch and hip joint motion with the exception of full adduction has been satisfactory. My own cases are too recent and too few (four cases) for final report but it is our intention to continue the use of the method.

#### COMMENT ON AUTHOR'S CASES

This report is based on the following personal experiences: (1) nineteen osteotomies for old intracapsular hip fractures, (2) four osteotomies for fresh intracapsular fractures upon which it is too early to report, though three seem to have a good result with bony union and (3) four osteotomies for malum coxae senilis without fracture.

A statistical study of these cases would be worthless and misleading. There were a number of bad results among the earlier osteotomies. With a better mechanical and physiologic conception of the problem, the results have been more satisfactory. This group of cases is too small for dogmatic conclusions but the impression gained is that fairly good restoration of function, usually with bony union, can be expected with osteotomy properly performed.

Malum coxae senilis is a form of degeneration in the head of the femur, probably due to a partial loss of blood supply. Observing revascularization in a partially dead head of the femur following osteotomy for non-union, it was decided to try this procedure for malum coxae senilis. The only variation in technic is that the osteotomy is slightly more oblique and the inner margin of the shaft is displaced inward always beneath the lower margin of the acetabulum. One patient is completely



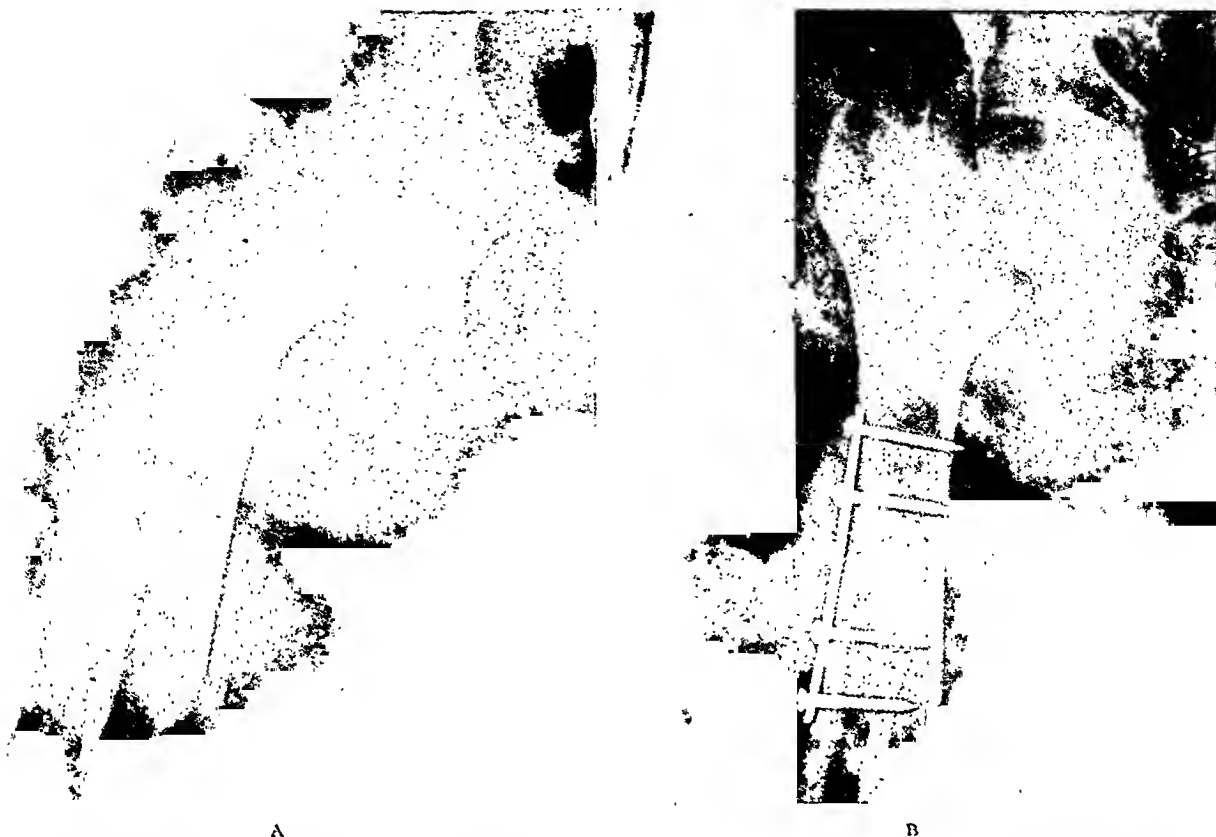


FIG. 3. A, old fracture of neck of femur with non-union and fresh fracture of shaft; B, preliminary repair of shaft fracture.

relieved four years after operation, one is improved and the other two are unimproved. These results are not spectacular but the intention is to use the method in a larger series. It must be admitted that my own experience with other operations for this condition have been disappointing. The Australian procedure, consisting of making multiple drill holes through the trochanter into the head to encourage new blood supply, has not achieved its objective in my hands but helped suggest the use of osteotomy.

#### SUMMARY AND CONCLUSIONS

1. The author's technic for osteotomy has been described.
2. Osteotomy seems to be the best procedure for all old hip fractures. It is safe and simple to perform and no gadgets are needed.
3. There are no contraindications to osteotomy referable to the condition or position of the fragments and there are a minimum of complications.
4. Osteotomy is useful in many other hip conditions such as *malum coxae senilis*.
5. Osteotomy may partially or completely supplant internal fixation in the treatment of fresh intracapsular fractures of the hip.



FIG. 3. C, subsequent osteotomy with bony union in both fractures.

6. Osteotomy, previously used chiefly on bad risks, deserves a better chance and better

technic in all types of intracapsular hip fractures.

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#### DISCUSSION OF PAPERS BY DRS. SIRIS AND MULHOLLAND AND DR. ASBURY

JOHN A. CALDWELL (Cincinnati, Ohio): This method of immediate fixation of fractures of the femur has very justly been accepted with a great deal of enthusiasm. It has been one of the major improvements, I think, in the handling of broken bones.

It is difficult to discuss Dr. Siris's cases here but simply to call attention to some of the high points. It is impossible to disagree with most of the things he has emphasized. Failure of union in these pinned hips generally falls into one of three classes: (1) failure of reduction, (2) failure of fixation and (3) an indeterminable factor which is generally spoken of as impairment of the blood supply, in which we cannot really fix the reason.

Dr. Siris mentioned one thing to which I would like to take exception that is, he emphasized in several cases the age of the patient as the factor in failure of the union or in producing union. So far as I am aware, if there is such a factor I do not know what it is. I have probably seen more failures of union in young persons, particularly in children, than I have in the aged. That, of course, has to be analyzed a little more deeply. There are so many more cases of old patients than there are of young ones that a failure of one or two cases makes a big difference in the percentage.

In failure of reduction, probably the most important factor I know of is a good, understanding x-ray service. I have had more failures in those

cases in which I have not been able to get that service than for any other one factor.

With the failure of fixation, the one feature in which I personally am interested is the type of fracture in which the head is broken off very high up on the neck that is, the proximal fragment is short. In those cases, they are very difficult to reduce. The fixation is difficult because you do not have much area of bone in which your pin can catch.

Another technical feature is that if you are fixing with a Smith Petersen nail, driving that in may cause the rotation of the proximal fragment so as to displace a good reduction. I have met that pretty generally now in those cases by discarding the Smith Petersen nail and using only the Austin Moore pin. These can be put in place simply by spinning them in and it is not necessary to use a hammer to place them.

I believe that Dr. Siris has given us a splendid résumé of these cases and what is particularly refreshing is the candor with which he refers to his mishaps and his failures.

KELLOGG SPEED (Chicago, Ill.): I have enjoyed these two papers very much. They open up a very large field of pathology, mechanism and treatment. I am very gratified also that the fracture oration I had the temerity to give some years ago in Boston, right on Smith Petersen's own home grounds and right at the time of the rising popularity of the fixation by his nail, has borne these results. That oration was purely provocative and the results as coming out in these papers are evidence of the fact that the fracture was not solved then and apparently is not completely so at this time.

Dr. Asbury leaves little approach for discussion, if you have read all his paper. Using his second point, the proper direction of osteotomy must not only insure the possibility of the desired angle of abduction of the shaft of the femur, but must assure a continued apposition of cut-through bone surfaces after the shaft fragment is shoved inward beneath the head. A very oblique angle of osteotomy may permit sufficient abduction of that leg but will not sustain continued later apposition of bone. I prefer high osteotomy at the level he describes, with such angle of displacement that the osteotomy plane will be about 200 degrees with the pelvic wall. Preservation of a periosteal bridge between trochanter and shaft may help to insure certain bony union but, after all, most of the osteogenic effort, as in intertrochanteric fracture, comes from the large surface of cancellous bone excellently supplied with blood, which is exposed by the cut and yet held in close enough contact to promote bony union, as after fracture.

Bone chips may enhance this union. To obtain them requires greater exposure and more local complicated cutting of bone, which may invite infection and spoil simplicity of technic. I have

not found them necessary in this highly osteogenic area.

The axes of the main bone trabeculae in the head, neck and shaft fragments must be brought into line and held there in a weight-sustaining position until bony union follows, by whatever means the surgeon elects. Certainly, some immobilization in this chosen position is indicated to avoid the adverse action of muscle pull on the trochanter and shaft fragment.

The failures of osteotomy I have seen depended upon these three factors: too great obliquity of the osteotomy, insufficient medial displacement of the shaft under the head, and too little provision for any immobilization or maintenance of post-operative position. Dr. Asbury is quite right in advising that this method is not a successful cure-all, simply by the twist of the wrist and a chisel. It must be well planned and anatomically executed in each instance.

CHARLES S. VENABLE (San Antonio Texas): I am going to discuss this from a little different angle, because the first eight of the various causes of non-union include mal-position and mal-use of mechanical devices or insufficient approach, and I want to take this from another standpoint.

First, let us assume that we have had a proper reduction and a proper application of the internal fixation apparatus, whatever it may be. We know that there is a certain percentage—how much, I cannot quote—of non-unions in those fractures of the neck of the femur which have been properly reduced and which have had proper internal fixation as far as we know how or what. As another cause besides the eight mechanical causes described in the paper, I want to take up the serious phase of insufficient blood supply in the neck of the femur as one of the major causes of non-unions of fractures of the neck of the femur.

We know that the large percentage of non-unions of the tibia, of the lower end particularly, is a question of blood supply, and I think that is a factor. I think all bone, in all fractures, depends upon proper blood supply for union.

We have found associated with necrosis, which Dr. Stueck and I reported some few years ago, that the transposition of muscle into the neck of the femur near its trochanteric base, through a hole about a centimeter in diameter and about a centimeter in depth, carries blood supply and permits ingress and egress of the blood supply into the neck

of the femur and on up into the head. For some four or five years now, we have had a most astonishing result of rehabilitation from the moth-eaten appearance of the neck of the femur after necrosis, in which these people are pain-free and have a regeneration of their cartilage and lose all of that necrotic appearance with which you are so familiar.

For that reason, we have done this in some ten or twelve cases, of delayed unions—not in the non-union class, of complete non-union in which there is a fibrosis between the ends even if they were properly set, because you cannot expect blood supply to jump across a gap—but in those cases of delayed union in which you may recognize, when you get into the tenth, twelfth or fourteenth week in older people, that there is no evidence of union. I do not speak of callus because you do not see callus in the neck of the femur, but at that period by a transposition of muscle permitting a greater blood supply into the neck, we have had the most astonishing results in cases of a progressive union, going on to union by virtue of that very simple procedure of the transposition of a segment of muscle inserted and fixed into the femoral neck distal (lateral) to the fracture, which is very easily done and in which there is no mortality and no morbidity to amount to anything.

JAMES J. CALLAHAN (Chicago, Ill.): There are just two points that I wish to discuss.

First, both essayists' pictures revealed that the lesser trochanter and the inferior border of the acetabulum were in contact and formed an articulation. I believe that most of our reconstruction operations are a failure because we do not remove the lesser trochanter. I think that if one will make it more or less axiomatic, that when the greater trochanter is removed the lesser trochanter should also be removed, reconstruction operations will be more successful. This procedure will eliminate the possibility of an articulation of the lesser trochanter on the inferior border of the acetabulum.

Second, where the head is dead or where it is fixed in the acetabulum, as in one of the cases shown, I think it is much better to take out the head and do a reconstruction, because there are two adverse conditions to contend with, namely, the dead head and the possibility of a non-union in the subtrochanteric osteotomy.

IRWIN E. SIRIS [closing]: I wish to thank the discussers.



# MANAGEMENT OF INJURIES TO LARGE BLOOD VESSELS IN WOUNDS OF VIOLENCE\*

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THE immediate seriousness of wounds of violence depends to a great degree upon the extent and kind of injury to the underlying blood vessels. Methods of controlling hemorrhage from wounds of large blood vessels have excited great interest among surgeons from the very earliest times, not only because excessive loss of blood is always the most serious immediate consequence of such an injury but also because an ample supply of arterial blood to the parts beyond the point of injury must be maintained or serious complications are certain to follow. Since the end-results of the emergency management of vascular injuries in battle casualties of World War II have been so discouraging, a review of the often neglected fundamental principles which govern arterial surgery is particularly fitting at this time.

Operative procedures which are directed toward the reestablishment of the continuity of large blood vessels must be done soon after the initial injury if physiologic restoration of the circulation is to be accomplished. The muscles of an extremity may undergo ischemic necrosis in six to ten hours if the extremity is deprived of an adequate arterial circulation.

In most wounds of violence which affect the extremities, there is also considerable damage to the surrounding tissues, especially the nerves and frequently the bones. The accumulation of blood beneath the deep fascia of such an extremity may further occlude by compression all available collateral arterial pathways.

Often there is associated with these injuries severe shock resulting from diminution in the blood volume with a precipitous fall of blood pressure. When injuries are very extensive, the primary objective of therapy should be to get the patient in the best possible general condition since any premature attempt to repair the vascular damage or to save the limb might easily result in the death of the patient.

## EMERGENCY TREATMENT OF VASCULAR INJURIES

The immediate treatment of any injury which involves large blood vessels must be directed toward the prevention of excessive loss of blood. The application of a tourniquet above the site of the injury to control bleeding must be discouraged since such a measure deprives the entire extremity of arterial blood. Even after a relatively short period of time, such ischemia may produce irreparable damage to the soft tissues.

When hemorrhage is less severe and there is the possibility of preserving the viability of the limb, the bleeding should be arrested by digital compression followed by compression bandages. The wound can then be packed with gauze and a reasonable amount of pressure can be applied through the bandage until the bleeding is completely stopped. The use of hemostatic agents such as "gelatin sponges" facilitates the control of such bleeding so that proper supportive treatment can be given to the patient before any definitive operation is attempted.

Care must be exercised in the use of hemostats to control bleeding from an injured large artery since permanent damage to the artery will be produced if the hemostat is applied to the normal arterial wall. If the wound in the artery happens to be a simple tangential laceration, the surgeon will then be deprived of the chance simply to reconstruct the artery by sutures and will be forced to rely upon the more complicated and less satisfactory end-to-end anastomosis to reestablish the continuity of the injured artery.

In addition to the direct attack upon the bleeding vessels, there are other valuable methods of diminishing the rate and amount of bleeding. With vertical elevation of the extremities and mild direct pressure in the wound the

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bleeding from almost any peripheral artery can be controlled until preparations can be made for more adequate hemostasis. Vertical elevation alone often suffices to stop the bleeding from a lacerated artery of the forearm, leg or foot.

If the injured artery is small and not readily accessible or if there is a general oozing from many small arteries and veins, we suggest that the wound be packed with gauze or better, "gelatin sponges," until the bleeding stops. The gelatin sponges can be left in place indefinitely and allowed to heal into the wound but gauze sponges must be removed within two or three days. If the bleeding persists and the patient's condition permits, surgical operation for definitive treatment of the injured artery should be undertaken.

The proper use of transfusions of whole blood and plasma in adequate amounts is essential to successful vascular surgery. We consider it absolutely necessary to restore the volume of blood to approximately the normal level and to maintain adequate fluid and protein replacement to overcome the shock and the peripheral ischemia which result from loss of large quantities of oxygen-carrying red blood cells.

A complete set of sterile instruments and materials necessary to control the bleeding in patients with injuries to large blood vessels should be kept ready for immediate use in the accident room of the hospital at all times.

In many gunshot injuries of the limbs or neck, external hemorrhage may be slight, or even absent, even when one of the main arteries has been injured. This may be accounted for by the contraction of the artery and the curling of the intima with obstruction of the lumen when the artery is completely severed. Although subsequent thrombosis within the artery may produce occlusion of its lumen, this should not be considered permanent since secondary hemorrhage may occur after several weeks when such a thrombus becomes softened and is detached. Tangential injuries or incomplete severance of large arteries may give rise to profuse hemorrhage because the edges of the injured artery cannot retract and obstruct the lumen. In such patients, a hematoma forms in the soft parts of the extremity and the mounting pressure within it tends to restrict the flow of blood from the opening in the artery. However, if this blood begins to infiltrate into the muscular tissue of the extremity, there will be serious compression

of the collateral arterial pathways with a further reduction of arterial blood supply. Reaction to this infiltrating blood causes edema of the muscles and multiple incisions in the deep fascia of the extremity may be necessary to decompress the muscles and prevent extensive gangrene of the distal parts of the affected extremity.

When the bleeding about the artery remains localized, it forms a pulsating hematoma which may eventually develop into a false aneurysm. It is usually wise to allow such a false aneurysm to become well localized, and when sufficient time has elapsed to permit the extravasated blood about it to be absorbed, the subsequent cure of the aneurysm by surgical operation will be greatly facilitated. Usually from two to three months should be allowed to pass before an elective operation on such an arterial aneurysm is undertaken. In some instances, however, secondary hemorrhage, dissecting hematomas or infection may make it obligatory to carry out definitive treatment at an earlier time.

In through-and-through bullet wounds of the extremities, when the external bleeding stops spontaneously and when no evidence of serious compression of the collateral arterial pathways is present, we do not believe that the artery should be exposed by an emergency surgical operation. Early exploration of the wound with its associated difficulties due to the extravasated blood around the site of injury may make the exposure of the injured artery difficult and necessitate its ligation thus endangering the viability of the tissues of the extremity.

If signs of an arterial or arteriovenous aneurysm develop, an elective operation should be performed weeks or months after the injury. Arteriovenous aneurysms may cause early, acute cardiac decompensation and for that reason may require operation without delay. Complicating lesions of nerves or bones should never change this attitude toward immediate operation since the repair of these structures is also more likely to be successful if done as an elective operation.

Much of the surgery upon large arteries, however, may be classified as elective surgery and careful study and preparation of the patient are essential if the surgeon hopes to obtain lasting relief without serious complications from his operations. Successful arterial surgery depends upon adequate exposure of the injured arteries by properly placed incisions of reason-

able length and careful dissection of the tissues with as little bleeding as possible.

#### PRINCIPLES GOVERNING DEFINITIVE TREATMENT

*General Considerations.* The successful repair of a wound of any large blood vessel is a difficult task and the surgeon must constantly bear in mind that blood vessels carry a remarkable fluid which normally has a tendency to congeal. The formation of clots of blood within a large blood vessel after it has been repaired by sutures, or at the site of the sutures themselves, usually results in failure to reestablish the functional activity and the continuity of the blood stream through the artery or vein.

Most arteries which require repair are either diseased or damaged by trauma; consequently, the physiologic considerations during operations upon such vessels are vastly different from those which concern the surgeon who plans to suture a major artery of a normal man or some experimental animal.

In addition to the problem of intravascular thrombosis in injured or repaired blood vessels, the surgeon is concerned with the adequacy of the arterial circulation to the parts of the extremity beyond the point of injury to the major artery. The factors which determine the state of the peripheral circulation under all conditions are of concern to all vascular surgeons and we must understand thoroughly the principles which govern the proper exchange of arterial blood in the peripheral parts of the body if our management of vascular injuries is to be successful.

*Collateral Arterial Circulation.* The advantages of knowing the behavior of the peripheral circulation in an extremity or in the brain after the main nutrient artery has been severely injured should be obvious to every surgeon. It is our duty to ascertain by actual tests what alterations in the efficiency of the peripheral circulation will take place if the major arterial trunk of that extremity is permanently occluded during any surgical operation. This is a point of practical as well as vital importance. If temporary occlusion of the injured vessel causes the extremity to remain cold and cadaveric in color in spite of a satisfactory environmental temperature, it is evident that any surgical operation upon that major artery should be postponed. If, however, postponement of the operation is not possible because of the nature of the arterial injury, the

surgeon must resort to every available means of restoring the continuity of the injured artery or of enhancing the collateral arterial circulation.

It is absolutely necessary to determine the patency of the communicating pathways between the vertebral arteries and the carotid arterial circulation before the obliteration of the internal or common carotid artery is undertaken. We have advocated the use of local anesthesia when the large arteries of the neck are to be exposed by operation so that cerebral effects after temporary occlusion can be studied for about fifteen minutes to make certain before these arteries are permanently occluded that the collateral circulation is adequate. Severe or fatal cerebral disturbances which follow the ligation of one common carotid or internal carotid artery are due mainly to anatomic anomalies of the circle of Willis. We have followed the suggestion of Matas<sup>1</sup> and have always applied an aluminum band when the common carotid artery was to be occluded, while the external carotid artery is always obliterated by a ligature. If the patient shows signs of cerebral ischemia within several hours after the operation, the aluminum band can then be removed from the artery with subsequent complete restoration of the function of the artery.

If the collateral arterial circulation is active enough to keep the distal parts of the extremity in proper circulatory balance in spite of the injury to or the occlusion of the main artery, we consider it inadvisable to spend the time and labor necessary to perform a successful repair of the artery, since a single ligature on the proximal and distal ends of a completely severed artery will usually suffice to prevent further extravasion of blood into the muscles or to the outside. This is usually true after injury of the external carotid artery, its branches and those peripheral arteries which are paired such as the radial and ulnar arteries and the anterior and posterior tibial arteries. Suturing of defects in arteries should be carried out only when the collateral arterial circulation is grossly deficient after injury which involves the internal or the common carotid arteries or the large arteries of the trunk or extremities. If the injury to the main artery is at a major bifurcation, all arterial branches must be ligated to prevent retrograde bleeding.

*Secondary Vasospasm.* In most individuals,



the sudden interruption of flow of blood through a large artery of an extremity is usually attended by marked vasospasm in the entire vascular bed of that extremity; consequently, the degree of arterial insufficiency is usually out of proportion to the local injury of the main artery. This secondary vasospasm must be relieved by reflex means since the local application of heat to such an extremity is fraught with great danger. Locally applied heat increases the local metabolism of the tissues but does not greatly increase the flow of arterial blood to the distal parts of that extremity; consequently, the deficiency of oxygen to the tissues becomes greater and local death of tissues frequently ensues. In such instances, the use of vasodilating drugs such as the oral administration of alcohol, the intravenous administration of papaverine or the intravenous use of tetra-ethyl-ammonium chloride is of great importance.

Leriche<sup>2</sup> has maintained for many years that injury to an artery or the application of a ligature to an artery produces reflex vasoconstriction and we have confirmed his observations that the resection of the injured or damaged portion of the artery will bring about some vasomotor relaxation in the bed of that artery. Since 1934, Leriche has advocated the infiltration of the sympathetic ganglia with novocain as the most direct means of providing widespread vasodilatation in the affected extremity. There is considerable difference of opinion about the necessity or even advisability of sympathetic ganglionectomy or ramisection in patients with acute arterial insufficiency following injuries to major blood vessels. We doubt very much if sympathetic ganglionectomy and the sustaining peripheral vasodilatation which it produces, is the best treatment for this type of arterial insufficiency.

*Therapeutic Stimulation of Collateral Circulation.* There are several different ways of stimulating the flow of blood through the collateral arterial pathways which should be kept ready for use. The intermittent compression of the artery, as suggested by Rudolph Matas, enhances the collateral arterial circulation but, in our own experience, the use of passive vascular exercises (pauaex therapy) is a quicker and more effective means of causing blood to flow through collateral arterial pathways. The physical means of bringing about a reactive hyperemia by venous compression, by the immersion of the other extremity in warm water, or the

production of vasodilatation by novocainization of the regional sympathetic ganglia should also be kept in mind as active means of enhancing the collateral arterial circulation.

We believe that the treatment by properly applied alternation of the environmental pressure in the form of passive vascular exercises will actively develop a collateral arterial circulation and will reduce to a negligible degree the secondary symptoms which follow arterial interruption or excision of arteriovenous aneurysms in the extremities.

#### OPERATIVE TREATMENT

*Occlusion of Large Arteries.* Contrary to general belief, there are still many dangers associated with ligation of large blood vessels. Although improvements in our surgical methods have lessened the dangers of secondary hemorrhage, it must be kept in mind whenever large arteries of the trunk or neck are ligated. In 1891, Balance and Edmunds expressed the opinion that the wall of the artery beneath the ligature may remain viable and the intimal surfaces will unite if they are brought together over a sufficiently wide area. Upon the basis of their studies they insisted upon the use of wide ligatures which were tied just tightly enough to approximate the intimal surface of the artery without causing any fracture of the arterial wall. Halsted and Reid found further evidence that the ultimate result of ligation of any large artery was directly dependent upon the rapidity of necrosis of the segment of the vessel included in the ligature as well as on the rapidity of substitution of fibrous tissue for this necrotic segment of the artery. By the use of wide ligatures or bands, therefore, the process of necrosis of the arterial wall will take place slowly and a complete substitution of dense fibrous tissues will ultimately occur.

*Suturing of Injured Blood Vessels.* Preservation of the continuity of a large artery is not without definite hazards. Even though the arterial repair is successful a false aneurysm may subsequently develop, especially when there is considerable structural change in the wall of the vessel or when there are multiple points of injury to the artery. We have always believed that a badly damaged artery or one which shows extensive degeneration should not be expected to perform its normal physiologic function again. When there is evidence of an active collateral arterial circulation,



it would seem to us to be unwise to run the risks of secondary complication which might follow the reconstruction of such a damaged artery. In elderly people, when there may be considerable arteriosclerosis present, we believe that reconstruction of an artery is contraindicated.

The repair of an arterial injury by suture is, of course, the ideal method of restoring the continuity of a large blood vessel and of preserving the flow of blood through that large vessel to the distal portions of the extremity. During World War I, Leriche pointed out that suturing of blood vessels was extremely difficult and usually impossible in wounds of war but in civilian practice favorable conditions frequently exist and wounds can be freed of gross contamination by *débridement* and thus converted into clean wounds. In the face of infection, secondary thrombosis of the blood vessels or secondary hemorrhage very frequently occurs. The adequate use of antibiotics and chemotherapeutic agents systemically reduces the incidence of secondary infection of these wounds.

A great deal has been written about the management of arterial injuries during the recent war by Elkin, Freeman and others. Freeman has had considerable experience in the repair of traumatic aneurysms of war with reestablishment of the continuity of the large arteries. Elkins' experience with arteriovenous aneurysms was very large and his methods of treatment were based upon the time tested principles of Halsted and Reid.

In civilian practice, the proper use of the anticoagulants, heparin and dicumarol, is of great value in making possible the prevention of intravascular clotting of the blood during the time the sutured vessel is healing.

The transverse suture of lacerations of the arterial wall has been recommended by Learmonth if the laceration has not involved more than one-third of the arterial circumference. Freeman's experience with transverse suture indicates that such a suture can be used successfully even though more than three-fifths of the vessel wall is lacking.

Transverse closures in the arterial wall may produce distortion of the blood stream. There is usually a loud systolic murmur heard over the part of the vessel which has been sutured. It is only when this murmur has a to-and-fro characteristic that it becomes truly significant. The fact that the transverse closure produces

a greater diameter to the artery at the point of suture overcomes the objection that encroachment upon the lumen will cause secondary changes in the part of the artery distal to the point of suture. It is our experience as well as that of Freeman, therefore, that transverse suture of a defect in the arterial wall is much more satisfactory than longitudinal suture or an end-to-end anastomosis.

There are numerous ways of placing the sutures to reduce the possibility of secondary thrombosis. The interrupted mattress sutures (Fig. 1B) cause the intimal surfaces of the blood vessel to be brought together without allowing any suture material to extend inside the vessel. If a continuous suture is preferred, the "in-over-and-out" or reversed Connell suture makes a satisfactory means of approximating the intimal surfaces of the blood vessel. (Fig. 1A.) The two needle "cobbler stitch" is rarely used today. It must be remembered that the lumen of the artery must not be constricted too much by the longitudinal suture line lest the artery distal to the point of constriction undergo changes which will eventually result in the formation of a fusiform aneurysm. This is particularly true of the great vessels of the neck and care must be taken not to encroach too much upon the lumen during the repair of the arterial wall.

*Non-suture Method of Arterial Anastomosis.* This method dates back to the original observation of Tuffier who used glass and silver tubes to bridge the gap between the ends of a severed artery. The more recent work of Blackmore, Lord, and Stefko has given better means of bridging such gaps in arteries by the non-suture method. They have advocated the use of Vitallium tubes either with or without a lining of vein. When such a tube can be lined with a fairly large vein, the danger of thrombosis within the tube is lessened. Their most recent suggestion of using small collars of Vitallium so designed that a free segment of vein can be transplanted by the non-suture method to bridge a gap in large arteries has proved of value when time and the location of the injury in the artery makes repair by suture inadvisable. (Fig. 2.)

The use of a simple Vitallium, glass or plastic tube to restore temporarily the arterial circulation may be life saving. In one of our patients who had both common carotid arteries severed

by gunshot wounds, the right common carotid circulation was temporarily reestablished by the use of an unlined Vitallium tube. The injury to the left common carotid artery was not disturbed because of the patient's serious general condition and there developed within a few days signs of an arteriovenous communication at that site. The patient lived and subsequently a free graft of saphenous vein using Vitallium cuffs and the non-suture method was used to reestablish the circulation through the right common carotid artery. (Fig. 2.) The Vitallium tube remained patent for only about ten days and eventually became occluded by a firm blood clot; nevertheless, we believe that the temporary reestablishment of the continuity of the carotid artery overcame the acute cerebral ischemia and saved this man's life.

Transplantation of segment of veins can also be done according to the method of Murray in which actual end-to-end suture of the artery and the free graft of vein is done at both ends of the graft. When such patients are properly heparinized, Murray has demonstrated that these grafts remain viable and eventually the segment of vein takes on the histologic characteristics of an artery as the result of increased pressure within its lumen.

There are many different methods of performing end-to-end suture and end-to-side suture of blood vessels. (Fig. 3.) The important point is to be certain that the intimal surfaces are brought together without intervening adventitial tissue and that no suture material remains within the lumen of the sutured blood vessels. (Fig. 4.)

The danger of thrombosis following the suture of an artery is not to be overlooked but with the proper use of the anti-coagulants, heparin and dicumerol, the danger can now be reduced to a minimum.

Reestablishing the continuity of large arteries of the extremities after injury may prevent the secondary circulatory disturbances which so frequently are present after the ligation of one of these important arteries. After simple ligation of an injured artery the collateral circulation may be sufficient to maintain the viability of the peripheral tissues but may be insufficient to permit the muscles to function normally under stress. Intermittent claudication is common after otherwise successful ligation of the large arteries above the knees.

#### LATE EFFECTS OF VASCULAR INJURIES

After any injury in the vicinity of large blood vessels the surgeon must constantly keep in mind the late complications of progressive arterial *thrombosis*, secondary *hemorrhage* or the development of some form of *aneurysm* at the site of injury.

*Thrombosis.* Either arterial or venous thrombosis of the ascending type may add greatly to the gravity of the situation. Venous thrombosis may lead to pulmonary embolism; when it is extensive in the smaller veins of the affected extremity, it may cause secondary disintegration of the muscles of that extremity. We believe that autolysis of the anterior tibial or calf muscles occurs more frequently after local venous thrombosis in the muscles than from moderate degrees of arterial insufficiency alone. The extensive thrombosis of the major arteries without adequate collateral arterial circulation will always result in mummification or dry gangrene of the distal parts of the extremity.

*Hemorrhage.* Late severe hemorrhage may occur if local infection is present. When there is clinical evidence of increasing size of the aneurysm or more pain radiating along the course of the artery with rising fever, one must suspect serious complications. Secondary hemorrhage in this type of aneurysm usually requires immediate surgical exploration of the wound with definite arrest of the bleeding by ligation of the injured artery regardless of the possible effects upon the peripheral tissues. Packing with gauze and the application of compression bandages are of little practical value in such instances for the secondary hemorrhage will almost certainly recur unless the bleeding arteries are occluded by ligation. In the presence of serious infection or bleeding, which cannot be controlled by conservative treatment, the aneurysm must be incised, the arteries above and below the sac ligated and all branches leading from the sac occluded by sutures or ligation. Such operations can be properly performed only when a pneumatic tourniquet is applied above the site of injury.

*Arterial Aneurysms.* The presence of an aneurysm entails various dangers. The form of an arterial aneurysm depends on whether a segment of arterial wall gives way or whether some small spot weakens. The diffuse weakening of the wall gives rise to the *fusiform aneurysm* while a weakening of one spot in an artery forms a *saccular aneurysm*. Long-standing sac-

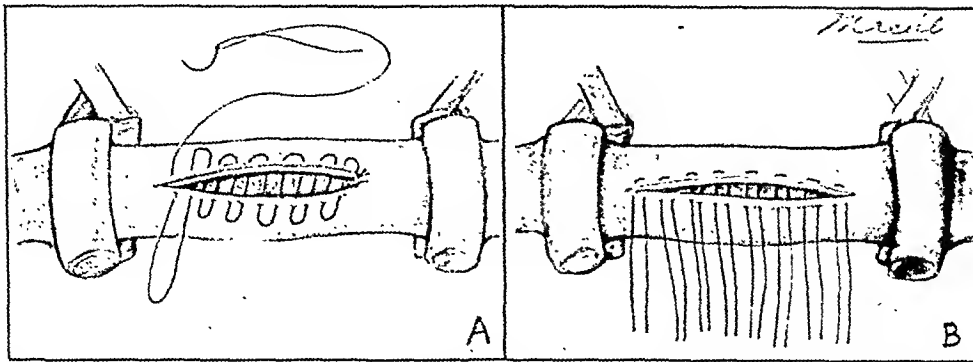


FIG. 1. Methods of suturing large blood vessels. A, continuous "in-over-and-out" suture or reversed Connell suture. B, interrupted mattress sutures which cause an eversion of the edges of the vessel with firm approximation of the intimal lining of the vessel.

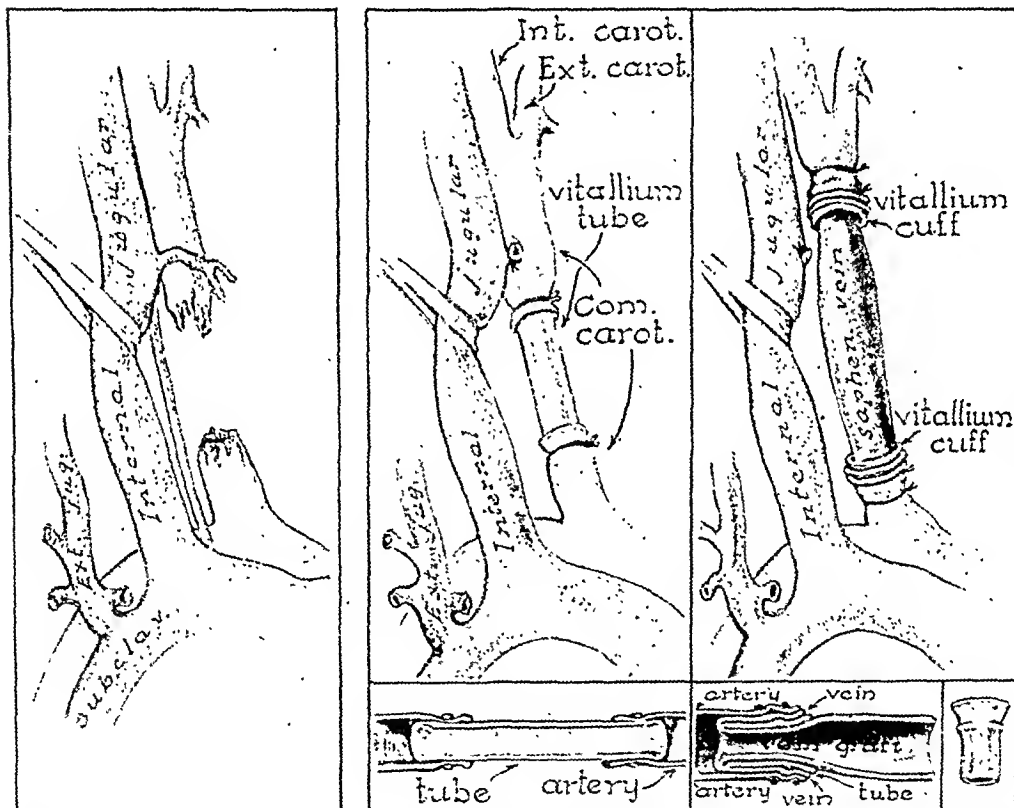


FIG. 2. Destruction of part of the right common carotid artery by a bullet. Temporary reestablishment of cerebral circulation by using an unlined Vitallium tube (emergency measure). Final reconstruction of right common carotid artery by the non-suture method of transplanting a segment of saphenous vein to bridge the gap between the ends of the artery.

cular aneurysms may stretch the entire artery so much that the position of the artery in relation to the aneurysm is eventually lost. The fusiform aneurysm may rupture at one place and assume the physical appearance of a saccular aneurysm. Such physical alterations of shape must be kept in mind by the surgeon who plans the operative procedure for the cure of an arterial aneurysm. True fusiform aneurysms

can rarely be treated successfully by plastic operations which are designed to restore the lumen of the artery. Saccular aneurysms, on the other hand, can often be cured by one of the ingenious operations devised by Rudolph Matas and which he designated by the name of restorative or reconstructive aneurysmorrhaphy. Cures may sometimes be effected by complete excision with restoration of the lumen

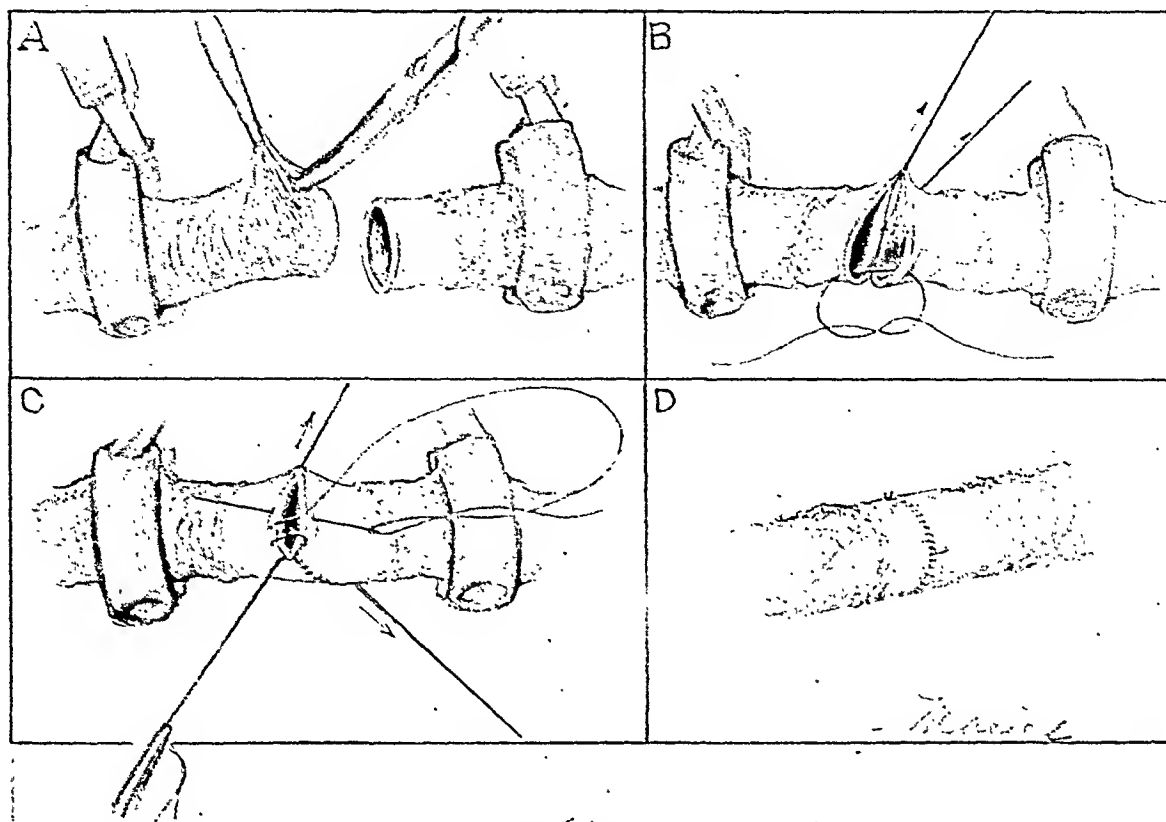


FIG. 3. End-to-end anastomosis of blood vessels by sutures according to the method of Carrel. Note the removal of the adventitia of the artery in the vicinity of the suture line.

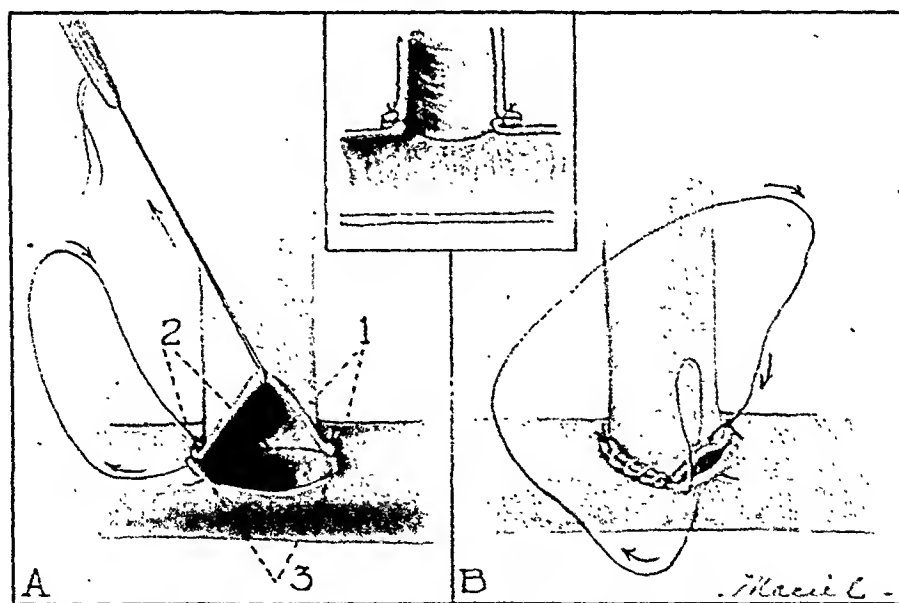


FIG. 4. Method of end-to-side anastomosis of blood vessels by sutures. This is a triangular method using a reversed Connell or "in-over-and-out" type of suture. Note how the intimal surface is approximated without having the suture material extend into the lumen of the blood vessel. Fine silk on atraumatic curved needles is used for all blood vessel anastomoses and repair.

either directly by sutures or by transplanting a segment of vein to bridge the defect.

*Dissecting aneurysms* may cause pressure upon nerves and give rise to pain or motor paralysis. Aneurysms may even erode bony

structure and then give rise to fatal hemorrhage into large body cavities. (Fig. 5.)

*Operative Procedures.* Operations for the cure of aneurysms must be carried out before extensive erosion of important structures takes

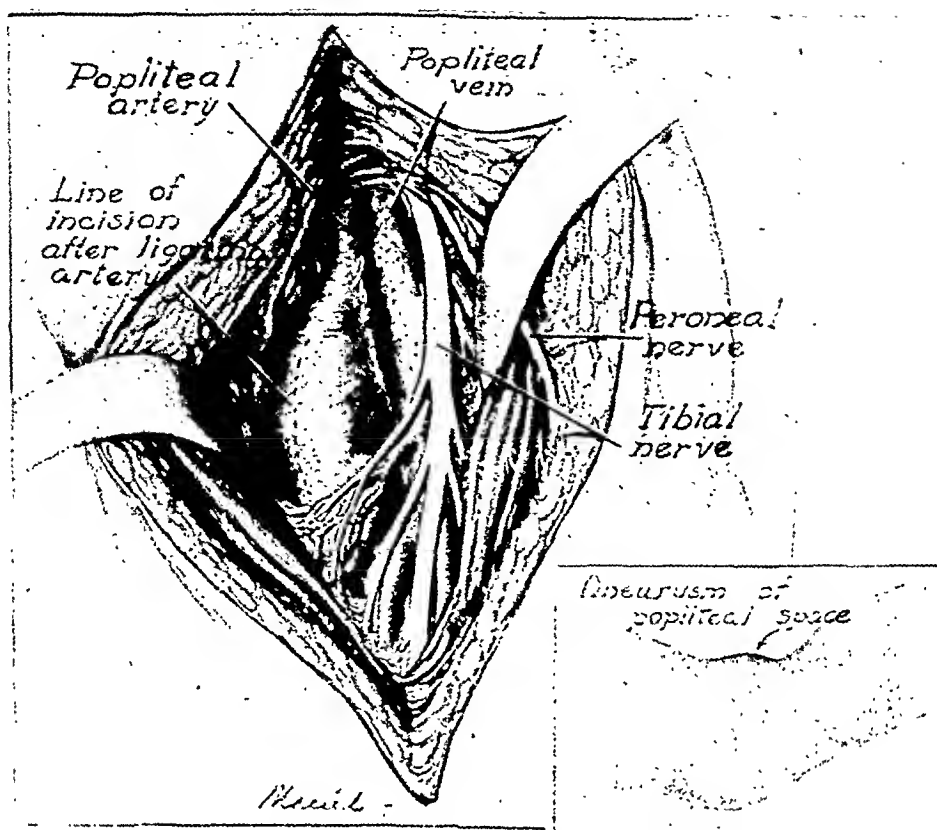


FIG. 5. Traumatic aneurysm of the popliteal artery.

place. If immediate operation is necessary because of bleeding, the artery can be occluded proximal to the aneurysm by means of a metallic band. Should the extremity then become dangerously ischemic, the band can be removed within twelve or twenty-four hours without producing permanent damage to the artery. If gradual occlusion of the artery cannot be tolerated by the patient, some restorative operation should be performed.

**Obliterative Endo-aneurysmorrhaphy (Matas Operation).** This operation is applicable to ordinary fusiform aneurysms. No attempt is made to reconstruct the parent artery and the arterial orifices are simply obliterated by sutures. By placing the sutures from within the aneurysmal sac it becomes possible to cut the sac off from the circulation without disturbing the adjacent collateral branches and without interfering with the nutrition of the wall of the aneurysmal sac.

**Extrasaccular Ligation without Arterioplasty.** We have usually used a modification of Antyllus' method of extrasaccular ligation of incoming and outgoing arteries in the treatment of aneurysms in the popliteal space. We have per-

formed an incision of the sac with evacuation of the clots and we have not observed any instance of secondary hemorrhage. The ligation of the artery far above the aneurysm, as advocated by Holman, may be a life-saving procedure when severe hemorrhage takes place; but we believe it increases the danger of gangrene of the extremity and does not cure the aneurysm.

Our modification of the Antyllus operation is indicated in certain types of fusiform aneurysms in which the wall of the proximal artery adjacent to the aneurysm is greatly thinned or is partially damaged. The objection that the extrasaccular ligation of the incoming and outgoing arteries might interfere with the collateral arterial branches is a just one; but if the condition of the artery near the aneurysm is not good, we believe that a much more secure obliteration can be obtained by applying a piece of cotton tape around the artery just outside the aneurysmal sac. (Fig. 6.) After this is done, the aneurysmal sac is opened, the clots removed and any arterial bleeding within the sac is controlled by the application of intrasaccular sutures as described by Matas.

**Restorative Endo-aneurysmorrhaphy with Ar-**

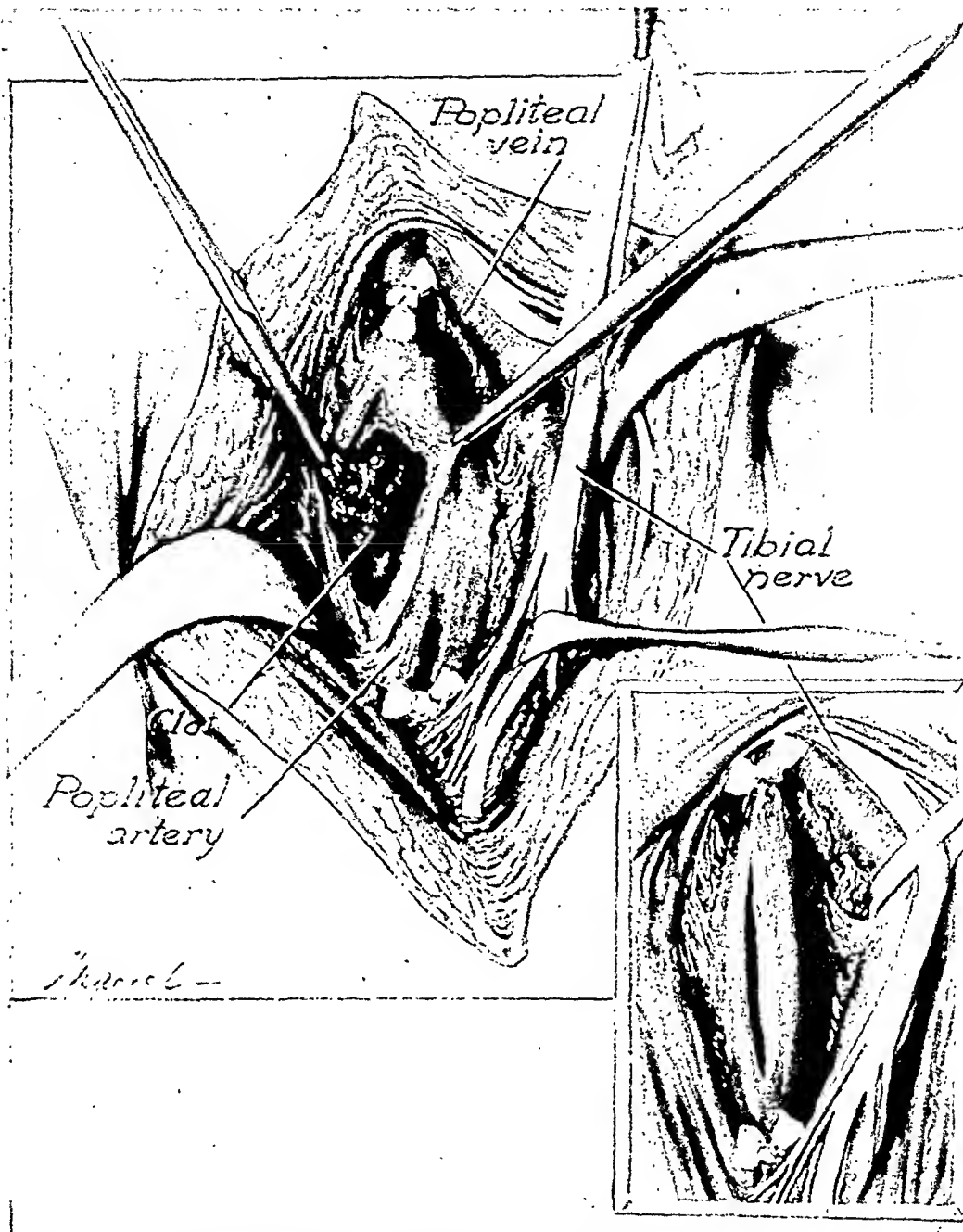


FIG. 6. Extrasaccular ligation of the incoming and outgoing arteries with incision of the sac and evacuation of the blood clots.

terioplasty (Matas). In those saccular aneurysms which result from partial injury of the arterial wall and which are the end result of pulsating hematomas, there is usually one orifice of communication with the artery. (Fig. 7.) Matas demonstrated that by opening the aneurysmal sac it was possible to repair the injury to the artery and thus restore its continuity. Such an operation, of course, must be done with the aid of a pneumatic tourniquet applied above the site of injury to the artery. This procedure is particularly applicable in the treatment of saccular aneurysms which de-

velop after injury to the large blood vessels by gunshot wounds, stab wounds, or penetrating wounds in which the wall of the artery is otherwise healthy and can be sutured satisfactorily.

**Arteriovenous Aneurysms.** The majority of arteriovenous aneurysms are the result of penetrating wounds which injure the artery and vein. During World War I it became apparent that arteriovenous fistulas between large arteries and veins frequently caused progressive damage of the heart. Reid made this observation numerous times and demonstrated that marked hypertrophy and dilatation of the

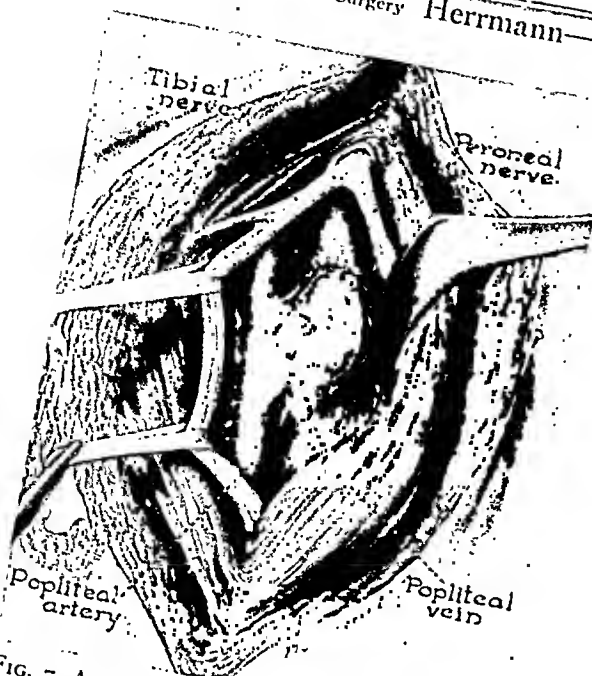


FIG. 7. Arteriovenous fistula between the popliteal vessels. Note the changes in the walls of the vessels at the site of the fistula.

heart resulted from large fistulas between the vessels of the neck, thigh or trunk. In several cases acute cardiac decompensation resulted

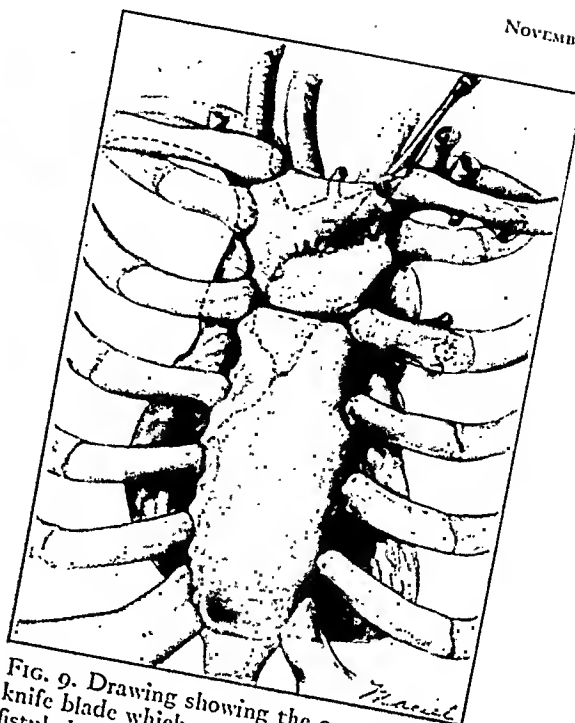


FIG. 9. Drawing showing the course of the knife blade which caused the arteriovenous fistula between the left innominate vein and the aorta at the base of the right innominate artery and the right common carotid artery.



FIG. 8. Quadruple ligation of the vessels involved in the arteriovenous aneurysm with complete excision of the portion bearing the fistula.

early in the course of the development of the aneurysm. It must, therefore, be borne in mind that it may be necessary to subject the patient to operation much earlier than ordinarily would be the case because of this serious complication. Reports in the literature show that the serious cardiac disturbances or decompensation may come as early as the fifth day after the injury. As a temporary means of relief to the embarrassed heart, Tixier and Arnulf suggested that the vein be ligated some distance proximal to the fistula; and after the cardiac decompensation has been overcome, the curative operation can follow as an elective procedure. The benefits of proximal ligations of the vein in large aneurysms has been observed by Stone, Holman and Matas and the procedure should be kept in mind as a life-saving procedure in those patients showing early signs of cardiac failure. It is well established that the arteriovenous fistulas act as a profound stimulant to the development of a collateral arterial circulation; for that reason most of the surgeons who deal with these conditions have advocated a delay of several weeks to several months before a curative operation is attempted. In our clinic it has been the practice to delay operation for



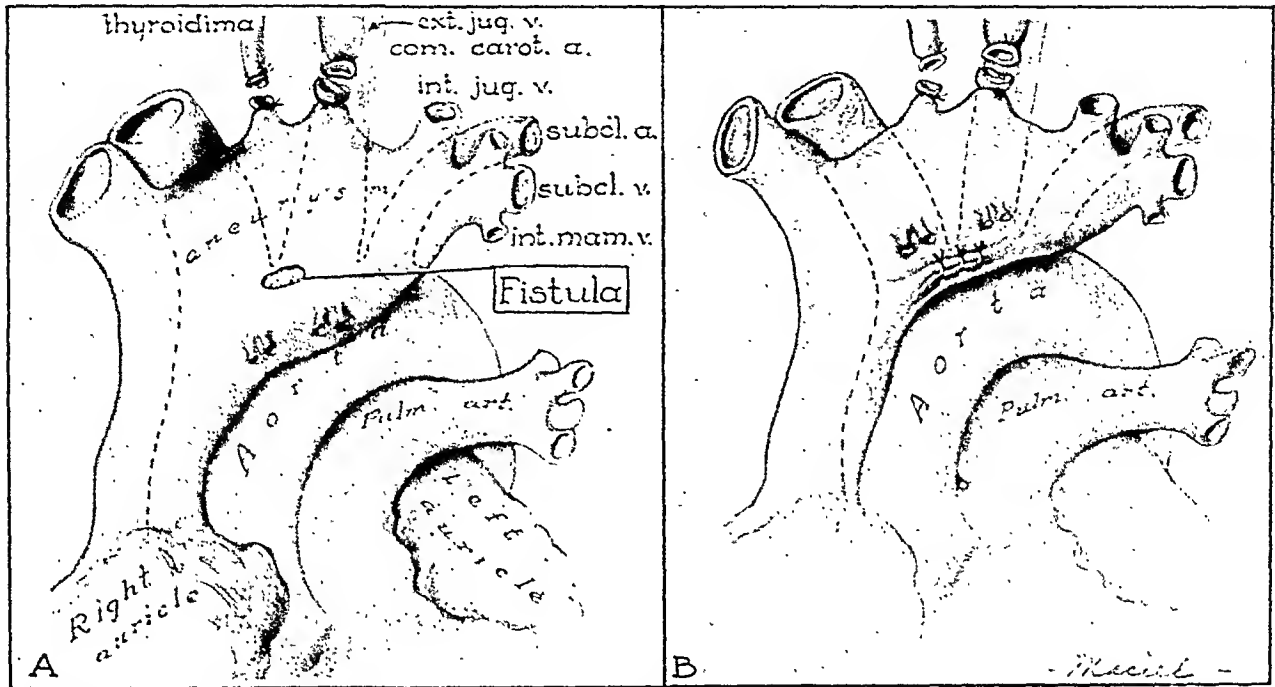


FIG. 10. Drawing showing the site of the arteriovenous fistula after the structures were exposed at operation. The drawing on the right shows the result of the exo-aneurysmorrhaphy with preservation of the left innominate vein and the drainage of the thoracic duct.

approximately six months, especially when the quadruple ligation or excision of the arteriovenous aneurysm is contemplated.

Arterial repair in the treatment of arteriovenous fistulas is not without its hazards and its value may be questioned. Since the occurrence of gangrene after arterial ligation in the

treatment of arteriovenous aneurysms is negligible, Freeman raises the question, Why subject the patient to the risk of repair? The answer to that question is relatively simple since in a careful study of the patients in whom ligation of a large injured artery was done, several observers have found varying degrees of chronic

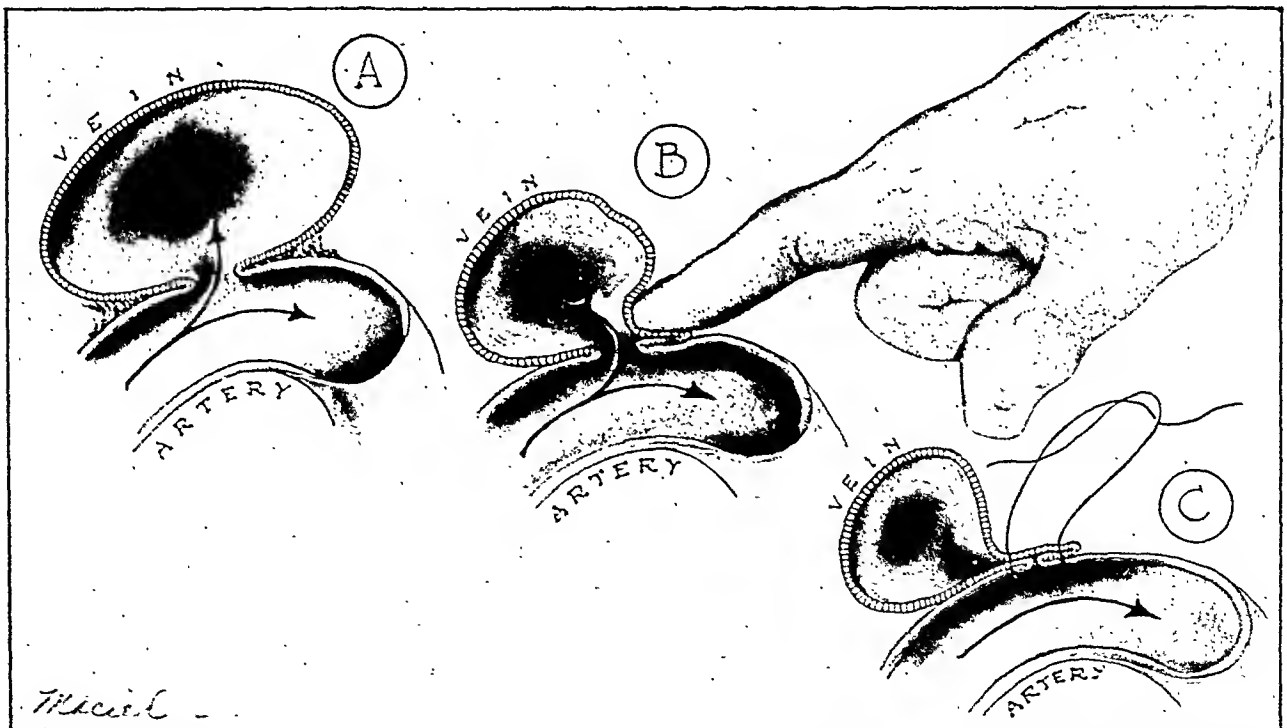


FIG. 11. Drawing showing the method of closing the fistula between the aorta and the left innominate vein and the method of preserving the patency of the left innominate vein by the method of exo-aneurysmorrhaphy.



ischemia of the extremity after an otherwise successful operation. Bigger emphasized this point when he stated that much has been written about the method designed to avoid serious ischemia or gangrene in curing aneurysms and injuries to important large blood vessels, but remarkably little consideration has been given to the sub-acute and chronic ischemia which subsequently develops in such extremities after the ligation of one of the large arteries.

The recent experience of Freeman supports the contention of many of us that early restoration of the continuity of the involved vessels can usually be done satisfactorily. This means a great saving in time of convalescence and hospitalization for the patient. Often after the quadruple ligation of arteriovenous fistulas there is sufficient circulation to care for the ordinary needs of the tissues at rest but there may still be evidence of arterial insufficiency with persistent symptoms of impaired circulation after normal walking. This type of disability is usually completely overlooked. In our own series of quadruple ligations and excisions, as well as in the series reported by Bigger, there are no instances of serious acute arterial insufficiencies, but about 25 per cent of the patients showed signs and symptoms of chronic, mild ischemia of the affected extremity. (Fig. 8.) There is no question but that the restoration of the circulation through damaged arteries, as was emphasized by Matas many years ago, is the ideal method of treatment. Bickham subsequently applied the Matas operation of intravascular repair of the saccular aneurysm to the treatment of arteriovenous fistulas. He was the first to suggest the transvenous closure of the defect in the arterial wall with the preservation of the continuity of the artery and vein.

The transvenous method of closing the arteriovenous fistula has some advantages; but it must always be borne in mind that additional openings in the veins on the opposite side may be present or other weakened areas may be overlooked, hence the aneurysm will not be cured. An objection to arterial repair which cannot be too strongly emphasized is the technical difficulties which such operations entail. Holman has repeatedly cautioned that successful repair of arterial injuries and the cure of aneurysms by transvenous repair depends so much on the ability to control completely all the bleeding. Freeman recently reported suc-

cessful repair in eighteen out of twenty-three patients with war injuries to the peripheral arteries. Only one patient developed a recurrence of an arterial aneurysm and one developed a recurrence of an arteriovenous fistula after transvenous suture of the opening was performed.

Only by completely isolating the artery from its surrounding tissue can the presence of other communication or other damaged areas in the arterial wall be discovered. Fusiform aneurysms have developed following the closure of arteriovenous fistulas by Reid and by Bigger.

After control of the major arterial supply has been accomplished, we believe that it is absolutely necessary to place a sterile stethoscope over the site of the fistula to make certain that no other arteriovenous communications are present. If the "to-and-fro" bruit continues, the surgeon can be certain that the aneurysm is not cured.

Arteriovenous aneurysms may give rise to large pulsating varices in the subcutaneous tissue of the extremities and thus may bleed profusely or ulcerate and even cause fatal hemorrhage.

#### POSTOPERATIVE CARE

Patients who have had an injury to large peripheral blood vessels must be watched very carefully with thorough inspection and palpation of the affected extremity at short intervals throughout the first twenty-four or forty-eight hours after the injury. We believe the application of plaster of paris casts should be avoided whenever possible, for the color and temperature of the extremity must be noted regularly; and at the first sign of circulatory insufficiency heroic steps should be taken to overcome this deficiency lest serious consequences follow in its wake.

Vasodilating substances should be given regularly for the first two days and we believe that the oral administration of alcoholic beverages is a very satisfactory way of producing peripheral vasodilatation. Drugs like "spasalgin" should be given intravenously every two to four hours and the papaverine contained therein will provide satisfactory peripheral vasodilatation. The complete novocainization of the regional sympathetic ganglia will also provide maximum peripheral vasodilatation and should be done every ten to twelve hours during the first forty-eight hours after the injury to obtain maximum clinical benefits.

We do not believe that operations upon the sympathetic nervous system are necessary or advisable as immediate treatment of extremely injured patients since the vasospasm associated with injury to large blood vessels is usually transient and can be overcome by simpler and much safer methods.

We believe it is extremely important to keep the extremity at the proper resting level. An ischemic extremity should be kept at a position about 6 or 8 inches below the level of the heart in order to provide the maximum exchange of blood in that extremity. If the extremity becomes mottled or cyanotic, elevation above the level of the heart for from one to two minutes may be advisable and gentle stroking of the skin from the distal parts of the extremity proximally will frequently free the superficial capillaries of the static blood. Heat must never be applied directly to an injured extremity which shows signs of circulatory insufficiency since heat only increases the local metabolism of the tissues without greatly increasing the supply of blood to the particular parts.

The use of heparin and dicumerol has proved to be extremely valuable in patients who have had an injury to a large peripheral blood vessel. Heparin acts quickly and can be given intravenously in doses of 50 mg. every four hours without fear of serious complications. The clotting time should be determined at intervals of about four hours and we have found a clotting time around fifteen minutes represents a satisfactory diminution of the coagulability of the blood. When heparin is given intermittently by the intravenous route every four hours, the clotting time varies a great deal during the four-hour period; and it is sometimes difficult to determine the mean clotting time. We have made a practice of determining the clotting time two hours after the material is injected into the vein.

Dicumerol requires from thirty-six to forty-eight hours to show its maximum effect, so it can be given simultaneously with the heparin and then the heparin injections can be discontinued as soon as the prothrombin time is reduced to a level of about 30 per cent of normal. Both heparin and dicumerol are powerful and dangerous drugs and must be used with caution and understanding. The use of these substances now makes it possible to reconstruct large arteries without having the results nullified by secondary thrombosis. If the coagulabil-

ity of the blood is reduced by these substances for a period of ten days or two weeks, healing of the injured or repaired artery or vein takes place and no further intervacular blood clots will form at that point.

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## DISCUSSION

R. ARNOLD GRISWOLD (Louisville, Ky.): Dr. Herrmann has brought out beautifully the principles underlying vascular surgery which he and others have preached for so long but which have not been as generally adopted as they should be.

As he said, restoration of the function of the artery should be our principal aim. From a practical standpoint, this is seldom done and not nearly as often as is possible. In a great many cases, of course, it is not possible. Restoration of continuity of an artery in the laboratory is a very beautiful procedure. The wound is usually made with a sharp knife and repair can be accomplished with excellent results. In acute clinical arterial injuries, however, the picture is usually that of a surgeon getting up in the middle of the night, opening up a limb and finding the acute arterial injury. He himself has not mastered the technic of vascular surgery or vascular suture and his operating room is not equipped with the fine suture material, the fine instruments and the other technical things that are necessary for such a procedure, so he ligates the artery.

It has been shown that whenever we interrupt permanently a major vessel supplying an extremity, that extremity is never again normal. It may live, it may look all right, but it never has the endurance or the strength or the resistance of its mate; so I think it behooves us to master the technic and have available at all times the technical equipment necessary for the restoration of continuity, either by direct union or by a vein graft, with or without the use of Vitallium tubes.

Probably we will not always be able to restore continuity. There is a time factor which does come into it. If the injury of the artery is over six to ten hours old, we are likely to have intervacular clotting, with thrombosis in the arterial tree, which is not reachable by any of our usual methods; so the suture and restoration of the lumen of the artery is not effective. Likewise, in many cases, the amount of artery torn and contused by bullet or shell fragment as distinct from a clean knife wound in the laboratory is so great that quite a length of artery may have to be excised before we can get to healthy enough tissue for an anastomosis. In such a case, only a vein graft would be useful.

The auxiliary methods of aiding circulation which Dr. Herrmann has mentioned are often neglected, particularly block of the sympathetic system, both in acute and old arterial injuries. I prefer when possible to do an operative permanent inter-

ruption of the sympathetic rather than too many repeated blocks. If it means a block every day over a period of ten days or two weeks, I would rather do an operation. It is much more satisfactory and certain.

Fasciotomy in cases of excess tension, beneath the deep fascia, has been greatly neglected. The failure to do fasciotomy in cases of high arterial pressure beneath the deep fascia due to an injured artery has resulted not only in loss of many limbs but also in Volkmann's ischemic contracture, both in the upper and lower extremities.

I should like to sound a note of warning about the use of tetraethylammonium chloride in these cases. It is being used improperly. Tetraethylammonium chloride gives you a complete sympathectomy. It does dilate the vessels to the injured extremity but it likewise dilates the vessels all over the body, reduces the general blood pressure and actually decreases the blood flow through the injured extremity. If you are going to sympathectomize for arterial injury, do not do it with tetraethylammonium chloride. Do it with sympathetic block or by operation.

The restorative surgery of aneurysm, both arteriovenous and arterial, is extremely important, because, as Dr. Herrmann brought out and as I said a few minutes ago, whenever we interrupt the main artery supplying any extremity, that never again is a normal limb. In the surgery of the older injuries, the aneurysms and the arteriovenous fistulas particularly, every effort should be made at restorative surgery or the use of a vein transplant in arterial aneurysms or transvenous arterial repairs in the case of arteriovenous fistula.

LESTER BREIDENBACH (New York, N.Y.): Dr. Jeré Lord and I have collected some ten cases in the last year and a half in New York City, in which individuals have had acute injuries to arteries in the extremities resulting in gangrene in most of them, with loss of a part or a great deal of the limb.

In a couple of these cases, as Dr. Herrmann mentioned, there is loss of a limb or certainly a considerable impairment of the function of that limb. There are two ways in which these acute injuries occur: one is in the operating room while the surgeon is operating. One of these cases is one in which a carotid sympathectomy was being done for a sinus syndrome and inadvertently the artery was injured. The surgeon was not well acquainted with the method of repair of the artery and had to ligate it and the result was, of course, a hemiplegia.

Another case was one which was brought to the hospital immediately (and most of these are brought to the hospital immediately because there is severe hemorrhage) in which a knife was accidentally dropped across the upper thigh and the femoral artery was severed.

We have analyzed these cases and found, even in

the operating room under the best of circumstances, that the proper procedure was not carried out because the surgeon was not familiar with arterial suturing. We have, therefore, started an educational committee, as a subcommittee of the Regional Fracture Committee in the City of New York, to try to educate the general surgeon in the methods that are used, which Dr. Herrmann and Dr. Griswold both mentioned, for primary anastomosis of the artery either by vein graft with the aid of Vitallium tube or by primary suture; and most of the time vein graft is necessary because of the elasticity of the artery. Its two ends part over a great distance so a vein graft is necessary. We believe that in this way a great many limbs in the course of a year will be saved if the surgeon has the armamentarium and the courage to go ahead and anastomose the artery. The armamentarium itself is simple and every operating room, we think, should have it. It consists of a few arterial clamps, with rubber-shod clamps (and there are various kinds on the market), No. 00000 or No. 000000 silk, and some Vitallium tubes. With that armamentarium, a good many of these limbs that are lost every year, I think, would be saved.

LOUIS G. HERRMANN (closing): I appreciate very much the remarks of Dr. Griswold and Dr. Breidenbach. I did not have time to cover my subject completely so I am happy that Dr. Griswold called your attention to the danger of using drugs which cause widespread vasodilatation when we are trying

to increase the arterial circulation to one extremity. DeBakey has recently emphasized the importance of producing only local vasodilatation in such patients.

I am happy to know that Dr. Breidenbach and his associates in New York are giving this problem serious consideration and are making proper equipment and facilities for the emergency management of vascular injuries available. To most of us this is evidence of surgical progress. We are convinced that many limbs and even many lives could be saved each year if all surgeons were alert to the importance of injuries to large blood vessels in wounds of violence. Prompt diagnosis of the site and kind of injury with as little delay as possible in carrying out definitive treatment and constant postoperative observation with immediate correction of secondary vasospasm have proved to be of utmost importance to the success of vascular surgery. We believe some limbs are sacrificed because the effects of arterial insufficiency are not recognized until extensive and irreparable damage to the muscles has already taken place.

We all must make a determined effort to teach our resident surgeons these important factors in the management of injuries to large blood vessels and then provide them with the facilities which will permit proper care of such injuries at any time of day or night. The progress in this important field of surgery will depend largely upon the success and thoroughness of such an educational campaign.



# THE ZERO HOUR IN THE TREATMENT OF TRAUMA

## AN ORIGINAL HYPOTHESIS

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IT is my firm conviction that there is a physical law of repair in the healing of all wounds. Time is the essence of that law and this is the law: *The healing of a wound is directly proportional to the timeliness of its aseptic coaptation.*

This approach to the healing of wounds, as far as the author knows, is both new and original in its conception. It deviates distinctly from the usual textbook description. It is primarily the straight physical and chemical approach to the healing of wounds.

In order to fit this discussion, let us define a wound as a break in the continuity of tissue. All things being equal, as long as continuity exists function is normal. Immediately ensuing a break there are certain definite changes which take place. These changes are at first physical and mechanical and later chemical and bacterial. It takes time for chemical changes to occur and time is required for the incubation of bacteria, both of which inhibit the perfect healing of a wound. The proper way to eliminate these is to repair the wound while it is still in the mechanical and plastic state. A piece of metal which suffers a complete fracture, if welded while fresh, results in good union. If left to rust or corrode, union is poor. So, in the healing of a wound, it is conditioned upon early approximation. Early, it is a matter of simple mechanical coaptation. The time of election is the period from zero to four to six hours following injury. The physical law of repair then holds good and is: The healing of a wound is directly proportional to the timeliness of its aseptic coaptation. Primary union then occurs and brings early restoration of function.

The secondary period, chemical and bacterial, needs elucidation in order to stress this law further. The chemical and bacterial changes are due to nature's oxidation principle. It is no chance affair that oxygen forms 21 per cent by volume of air, eight-ninths by weight of water, 50 per cent of the earth's crust and one-half of all plant and animal life including human body

as well. Oxygen is the disintegrating principle of life, working night and day to dissolve, separate, pull apart and dissipate matter. It causes iron to rust, copper to tarnish, paints to fade and wood to rot. It is the prime factor in the law of conservation of energy. In the human body oxygen is carried in loose combination in the blood stream. The vascular tree is a closed system of oxidation. Oxidation is both upbuilding and tearing down. The best repair of wounds is attained in the pin-nacle in between.

For the purpose of illustration I will cite a few instances:

I will first bring to your attention a man with hot solder covering that most important entire pupillary area of the eye. A solid patch  $\frac{3}{8}$  inch in diameter deeply imbedded was removed immediately by a painstaking and very competent eye man without any residual opacity.

Some thirty years ago when radical dissection (and I mean radical and complete dissection) was the meticulous procedure for tubercular glands of the neck, after carefully dissecting it out and delicately isolating it, the spinal accessory nerve was cut inadvertently, spelling the much dreaded shoulder drop. Fortunately the neurolema of the nerve was immediately sutured with fine arterial stitch with resultant restoration of function and no shoulder drop occurred after two months' time had elapsed. (We now know that a nerve will grow under such conditions at the rate of two inches in a month.)

Another case was that of a stone laid down in the salivary duct (Wharton's duct) which caused a complete block of the duct with consequent swelling of the gland, illustrating the purely chemical, physical and mechanical nature of the human body.

Another instance is that of a fracture of the right radius  $1\frac{1}{2}$  cm. proximal to the distal end with complete posterior displacement of the distal radial fragment. Reduction was made within an hour of the accident. I wish to call attention to the pressure thrust of the sharp

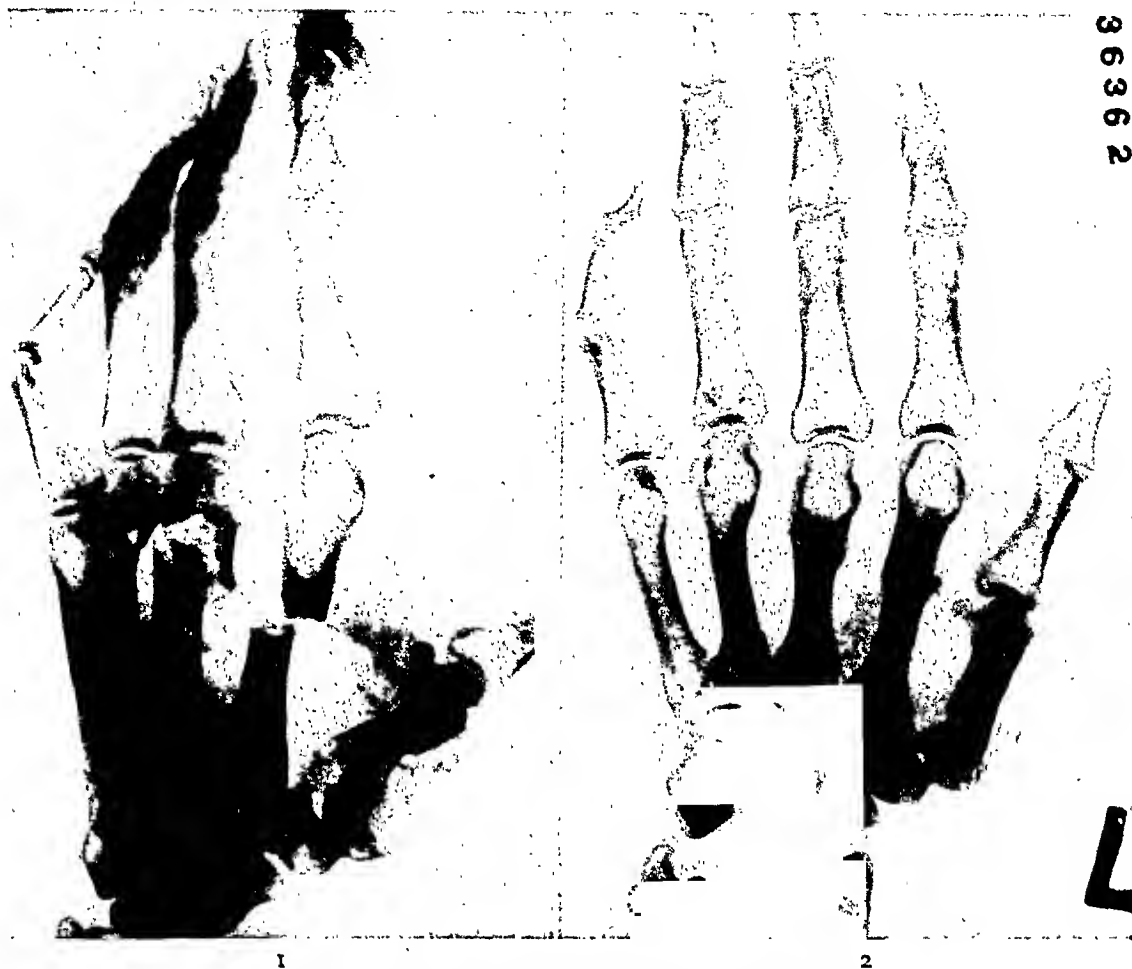


FIG. 1. Case of injured hand immediately following injury.

FIG. 2. End result of fractured hand shown in Figure 1.

spicules of bone using the homily, sitting down on a chair as contrasted with sitting on a tack. Pressure is the force applied to the unit of area. In addition to that is the matter of decreased surface tension in a fresh wound.

Another case is that of a ruptured gastric ulcer (incidentally, the second such occurrence in the same individual) repaired immediately after perforation.

Still another case is that of an oil tank truck driver who was changing a tire at 11:00 P.M. His left hand was caught between two tires when one of them blew out 65 pounds of air pressure, sending a portion of the tire rim through his hand against the rim of the second tire, a smashing injury involving all of the metacarpal bones of the hand—truly “smashing” as the word connotes—with massive flattening, scattering, and final friction and tearing. An explosive thrust of soft tissue against the firm, unyielding metal produced multiple compound comminuted fractures of all five metacarpal bones and a destructive laceration transversely across both the

palmar and dorsal surfaces of the hand with dirt, rubber and debris driven into the soft structures. The bones, unyielding, fractured, and soft tissues, tendons, muscles and nerves were simply brushed aside by this sudden terrific force. (Fig. 1.)

Under pentothal sodium, at 1:00 A.M. I began washing with soap and water—more soap and water—and carried out a thorough cleansing and débridement of the entire wound. Small fragmented particles of bone and all discernible foreign matter were removed. The gross fractures were wired with fine No. 30-gauge wire; bleeding vessels were closed with fine silk. Sulfanilamide and vaseline gauze were spread into the wound and the skin was closed with fine silk and a firm foam rubber dressing applied with plaster of paris cast over all, the final touch being given at 4:45 A.M.

Purposely do I mention the element of “time,” for it is brought home here in its full force. This man’s hand healed by primary intention with minimal edema and swelling and early restoration to function which brought

him back to his full and heavy duties as an oil tank truck driver at the end of two and one-half months. (Fig. 2.) The successful issue in this case was absolutely due to adherence to proper asepsis, perfect hemostasis, and careful and early coaptation of wound edges *before destructive secondary forces had a chance to take place*. This is a perfect illustration of the law: *The healing of a wound is directly proportional to the timeliness of its aseptic coaptation*.

#### DISCUSSION

ARTHUR R. METZ (Chicago, Ill.): The author has selected a very appropriate title for his paper, "The Zero Hour in the Treatment of Trauma," and stated as a law the principle that most expe-

rienced surgeons practice in the treatment of trauma: "The healing of a wound is directly proportional to the timeliness of its aseptic coaptation."

Experience and time have proved that the sooner a wound is thoroughly cleansed and the anatomic structures repaired and replaced as well as conditions permit, the best wound repair will be obtained.

The "Zero Hour" means "at once," and this principle has to be restated frequently in order to impress upon the students, interns, residents and younger surgeons the importance of giving emergency treatment to all wounds.

The author is to be commended on the selection of the title of his paper and the designating of a law: "The healing of a wound is directly proportional to the timeliness of its aseptic coaptation."





# A STUDY OF BONE MATRIX\*

## THE APPLICATIONS OF ITS REPLACEMENT WITH ARTIFICIAL SUBSTITUTES

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THE advances in the control of infection, especially in compound fractures, during the period of the past war experience has given us problems in reconstructive surgery for which we were incompletely prepared. Because the quality of surgery was high and the urgency of amputation was postponed many times, we inherited, so to speak, extremely complex mutilations which in the First World War would have been solved by amputation. The quality of surgery reflected the extensive use of blood and blood fractions in combating shock and saving life. Our increased knowledge of the physiology of shock and burns as well as of infection saved many lives which otherwise may have been lost. The advances in knowledge and technic, therefore, saved lives and extremities. It also gave us more complex problems which involved at times, loss of skin, loss of bone, partial destruction of muscle and nerve, but saved the extremity as a whole.

The need to replace bone substance in extremities whose soft parts were relatively intact sometimes exhausted the supply of long bone autogenous grafts. Restitution of the patient depended upon replacement of bone. Parallel problems in the replacement of nerve and skin concern us all, but for this discussion the problem is the replacement of bone. We undertook, therefore, to study the influence of artificial bone matrix substitutes on the tissue of the host site.

The biology of the bone matrix must get more study. Much emphasis heretofore has been placed on the cellular constituents of bone and on the mineral composition. Our knowledge of bone repair has been increased by these

studies and by the studies of the enzyme phosphatase. But the basic process of bone healing is still unclear.

It is our purpose here to report some of the preliminary work done on the study of artificial matrices. It is because the process of bone production is incompletely understood and that many applications may be derived from the use of artificial bone matrix that the Office of Naval Research\* is supporting these studies. If others will attack the problem of bone production, it is our hope that reconstructive problems contingent upon it will move toward a natural solution.

### SUBSTITUTION FOR NATURAL MATRIX

Any attempt at external or internal fixation by plaster, pins or plates is an effort to substitute for the bone matrix which, by trauma or disease, has lost its integrity. Onlay, chip and sliding grafts are operative efforts to guide the reparative matrix to replace the old. All factors which may influence the process of bone repair are of interest, naturally, but before the use of artificial matrices is considered, certain preliminary experiments were done to test again the influence of bone salts.

### INFLUENCE OF MINERAL ELEMENTS

The addition of denatured bone powder to the host tissue in the absence of living bone is insufficient to cause bone production. This holds true whether the denatured bone is de-

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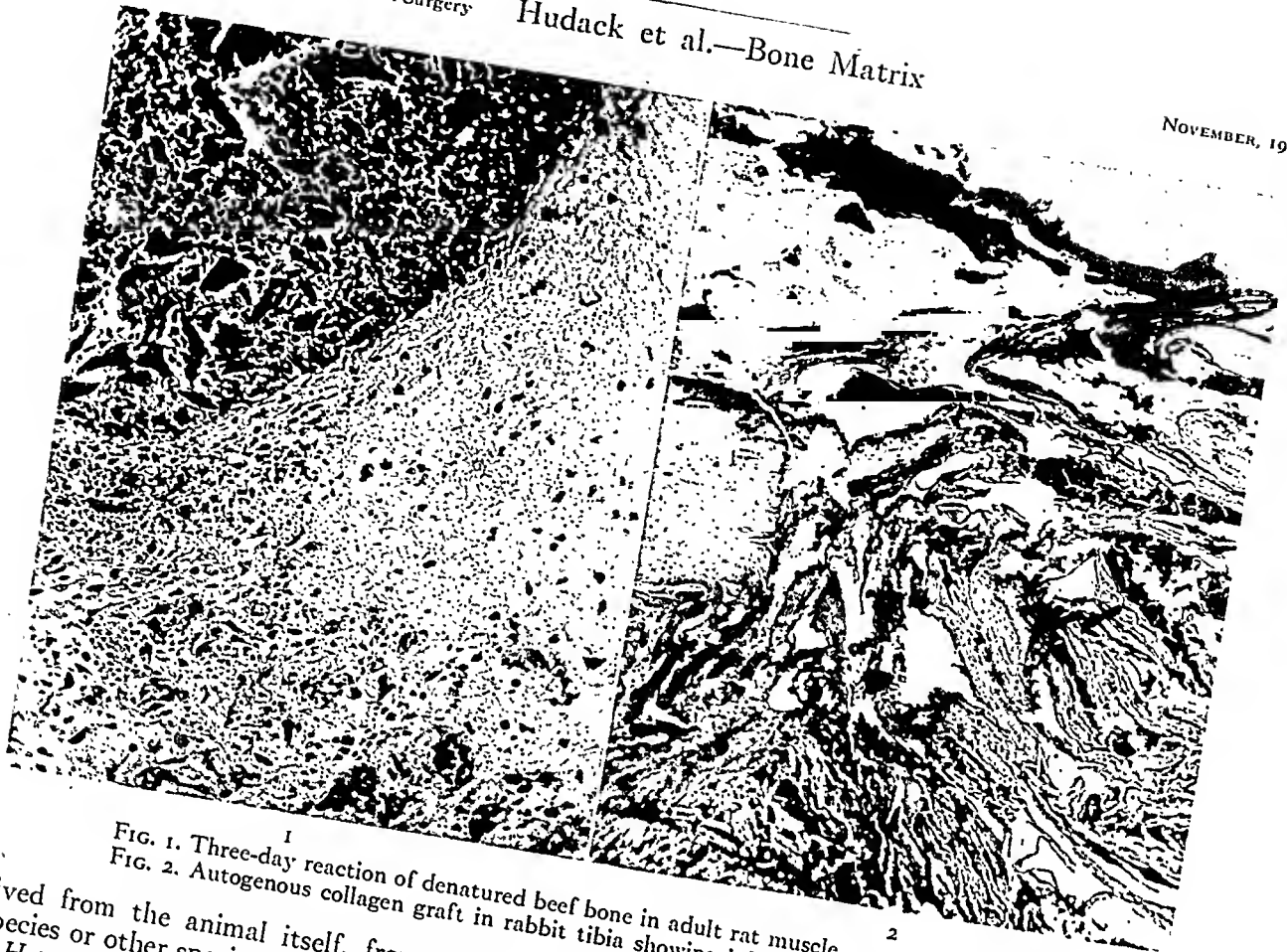


FIG. 1. Three-day reaction of denatured beef bone in adult rat muscle.

FIG. 2. Autogenous collagen graft in rabbit tibia showing inhibition of bone production.

rived from the animal itself, from the same species or other species.

**Heterogenous Bone Salts.** In a series of thirty-two rat experiments under standard laboratory nutrition and care, sterile powdered beef bone, previously extracted with 5 per cent sodium carbonate and acetone and washed (final pH 7.3-7.4), was injected or operatively placed into rat muscle separated from bone. In various combinations of circumstance, muscle was used which had been prepared by injury, operatively, or by injection of alcohol—50 per cent and 15 per cent solutions. The animals were sacrificed three days to several weeks after the bone powder had been placed.

The findings in these experiments are as follows: The early acute reaction to three days includes some hemorrhage, a mobilization of neutrophils and an early organization of fibrinous and cellular membrane, walling in the donor bone by the host tissue. (Fig. 1.)

As the process became older the neutrophils began to disappear and cells of the lymphocytic series began to dominate. The cellular debris of the neutrophils gradually was taken up and fibroblastic infiltration progressed. By four

weeks only some of the bone powder debris remained and giant cells were more and more in evidence. At no time in the process or in any individual specimen where the preliminary or operative trauma did not involve bone itself, did bone production take place at the site of reaction about the bone powder.

The preliminary trauma, by injection of 15 per cent or 50 per cent ethyl alcohol or by preliminary operation, did not appear to influence the ultimate nature of the tissue reaction. In other words, the presence of bone salts in muscle with or without previous traumatization, is in itself, insufficient to cause bone production. It is to be borne in mind that this is for denatured beef bone powder in rat muscle.

#### TRAUMA INVOLVING BONE

In another series of 100 experiments carried out in adult rabbits, the rat experiments were repeated in part. Injury to cortical bone was a variation of operative circumstance added to the experiments. The preliminary series, which did not involve bone injury, again showed no bone production at the site of beef bone powder in rabbit muscle either injured or uninjured. In

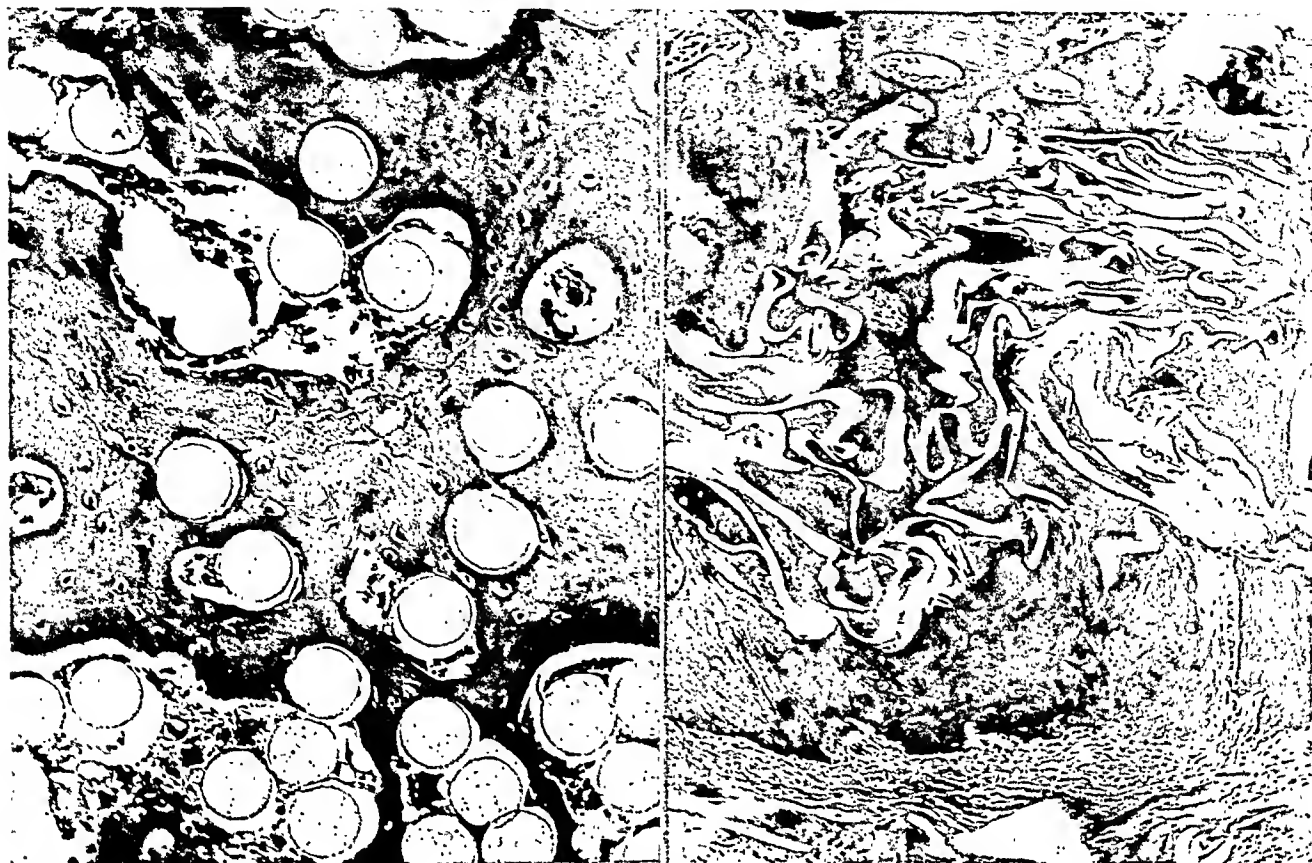


FIG. 3. Medium high magnification of section of bone matrix incorporating nylon filaments.  
FIG. 4. Lucite shreds incorporated in bone matrix.

the series which involved bone injury, matrices were used in connection with bone powder seeding and with the matrices alone for control.

Native rabbit collagen derived from fascia, either processed or used as an unprocessed autogenous graft, appeared to hinder bone production. It resisted revascularization and absorption and appeared as a barrier to bone formation whether it came from tendon, fascia or devitalized periosteum. Its combination with beef bone powder appeared to make no essential difference ultimately. (Fig. 2.)

By contrast, the use of monofilament nylon\* appeared to place no barrier to the formation of bone unless certain other factors interfered. If the matrix mass was tightly packed, bone healing was interfered with. Indeed, in some dog experiments to be considered in more detail elsewhere, it was sufficient to promote non-union. However, the individual fibers appeared quite inert and numerous examples of the filaments completely enclosed in bone are present in sections (Fig. 3.)

\* Provided through the courtesy of E. I. Du Pont De Nemours & Company, Inc., Rayon Department, Nylon Division, Wilmington, Delaware.

Polymerized methyl methacrylate was also studied in shreds and filaments and, despite some variability, appeared to be quite inert.

In some experiments, the well dried methacrylate polymer appeared to be as inert as nylon. Certain of the shreds appeared in section to be completely surrounded by bone. In some experiments, "lucite" appeared to be quite irritating to the host site tissues. This peculiarity of behavior is explicable on the basis that drying may not have been complete, the monomer and chloroform solvent persisting. In still other examples, in which the threads had been allowed to stand too long in alcohol for sterilization, there may have been some depolymerization. (Fig. 4.) The use of rabbits in these experiments, employing the tibia or the femur, was not entirely satisfactory. The results were sometimes obscured by secondary fracture and infection.

The study of vitallium as a replacement or substitute for bone matrix has been reported by Venable<sup>1</sup> and except for certain technical defects, appears virtually inert as far as tissue reaction is concerned. Vitallium has been applied successfully many times in its clinical use

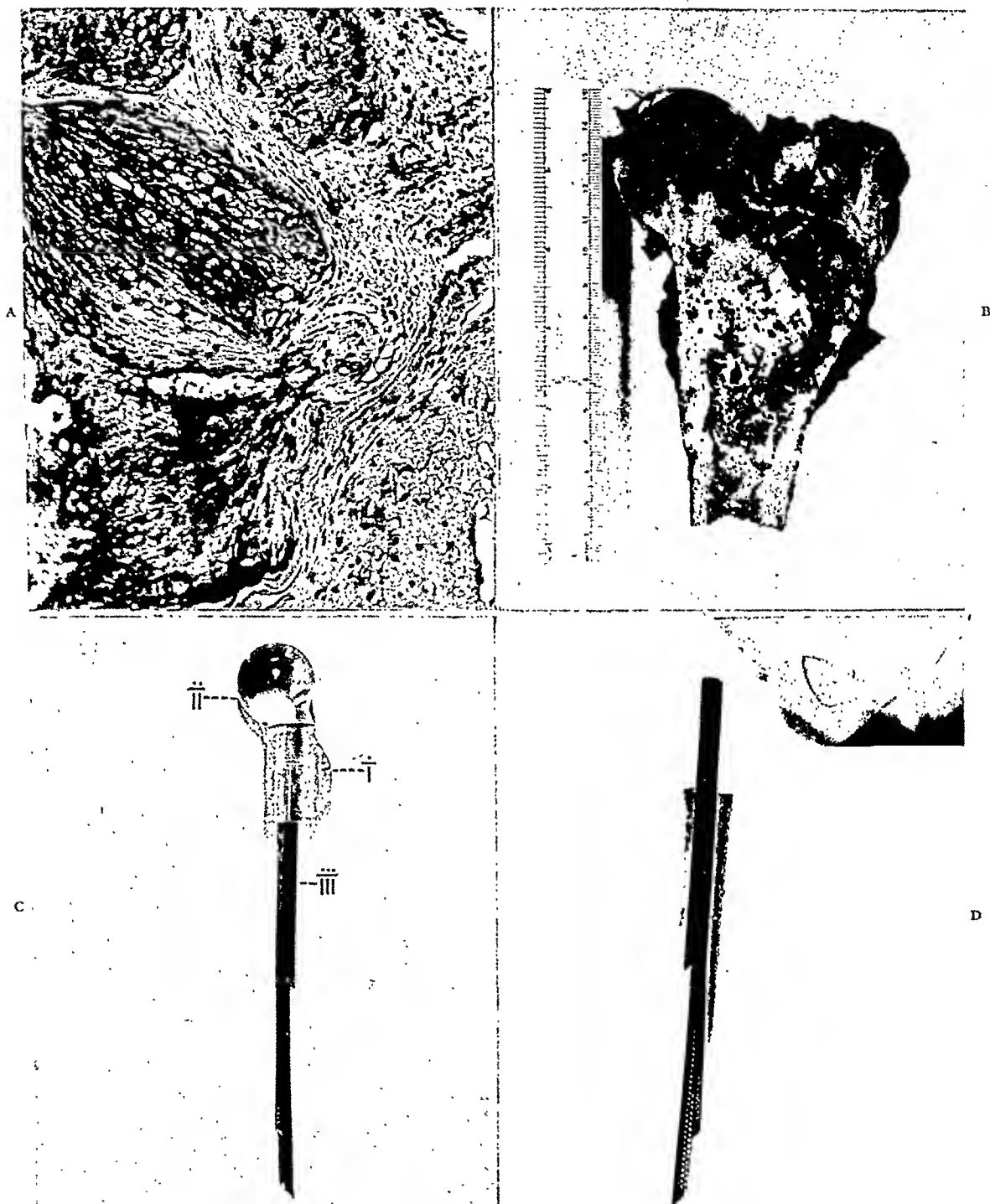


FIG. 5. A, microscopic section of well differentiated chondrosarcoma. B, longitudinal hemisection of postoperative specimen. C, anteroposterior view of articular replacement element. Note: i, the reattachment flanges; ii, the head element; iii, multiple perforated intramedullary pins. D, postoperative x-ray showing element in place three months after operation when patient was weight-bearing.

for internal fixation of fractures and in cup arthroplasty.

The use of stainless steel chrome nickel alloy has been studied and reported elsewhere.<sup>2,3</sup> Its use more recently for intramedullary fixation of fractures was extensively reported in foreign literature following its introduction for that purpose by Küntscher.<sup>4</sup> Chrome nickel alloy alone and in combination with lucite is being studied at present by the authors, both as a substitute for bone matrix and in articular replacement. This work is not, as yet, ready for publication. One instance of its clinical application may engage your interest, however; it is a case which, as yet, has not a sufficiently long follow-up for a case report and will be cited merely as an application of the work being reported here. (Fig. 5A, B, C and D.)

On January 30, 1947, D.S.\* a thirty-eight year old white woman was operated upon and a chondrosarcoma (Fig. 5A) involving the upper femur was excised. A replacement element was substituted for the excised portion. (Fig. 5B.) The articular element was lucite and the multiple intramedullary pins, having multiple perforations (Fig. 5C), were of chrome nickel steel.

The patient was out of plaster and capable of bearing full weight at nine weeks. (Fig. 5D.)

#### THE MATRIX

The investigation of matrices involves a dual problem. In one, we seek to find or develop a matrix which in a microscopic sense is inert and can become incorporated in the tissues of the host site. It must not inhibit bone formation and must be capable of becoming the physical vehicle and strut work to make possible the development of artificial grafts when the factors regulating bone production are more completely understood. Some work in this direction is reported by Blum<sup>5</sup> using phosphatase and lucite. A subdivision of this first phase of the problem is the development of a physical matrix for reconstructive work which may be utilized in regions of questionable sterility, such as in maxillofacial defects and old infected lesions. To avoid sequestrums, this matrix must be tissue soluble. The work on the tissue soluble matrices is not sufficiently developed to report here. However, gelfoam and fibrin foam and others are under consideration.

The second phase of the matrix problem is to find one with physical and biologic qualities which can withstand the strain placed upon it as a substitute for bone but which at the same time, is sufficiently inert to permit the formation of bone around it. This latter application, for example, would be very important in problems of loss of substance in long bones or in excisions of neoplastic and other lesions with necessity of extensive grafting or other replacement.

The first phase of this problem is now being investigated by the authors and some experiments carried out in dogs may be reported in part.

*Bridging of Bone Defects.* A series of forty-two experiments were set up in dogs in which the nature of repair was studied after the creation of a gap of 1.5 cm. in dog radii. A gap of this size in adult dogs almost invariably goes on to a fibrous union. In control experiments the matrix to be studied was used alone. Under surgical asepsis, the dog radius was exposed in its mid-portion and the 1.5 cm. segment excised. The resulting gap was filled with the matrix and the wound closed surgically in layers. In all the control experiments, non-union resulted. The nylon and lucite threads when loosely packed did not inhibit the formation of bone. The bone matrix was capable of growing through the matrix gap. In some places, the donor matrix strands were completely surrounded by bone and became incorporated into the host tissue. If the packing of the gap was too dense, the conditions for bone matrix deposition were disturbed and the donor matrix was virtually rejected; in other words, very little bone matrix grew about the donor shreds.

Occasionally, when the lucite matrix was inadequately dried or proved irritating to the host tissue, it was walled off and not even fibrous tissue would invade the donor mass. This happened with nylon, too, if the packing was too tight. The excised portion of the radius was usually saved. It was cleaned of soft tissue and marrow and preserved in 70 per cent alcohol. This section of the radius, and in a few instances rib substance taken out at the first operation, was cut into a fine powder with a rotary file and used for autogenous bone powder. It was processed and denatured with the same technic as the beef bone powder for the rat and rabbit experiments.

\* By courtesy of Dr. S. R. Gaston of The Fracture Service Staff, Presbyterian Hospital, New York City.

There was deposition of bone matrix in the presence of lucite and nylon shreds. The addition of autogenous bone powder to the lucite and nylon filaments did not inhibit bone production nor did it appear to stimulate it. Beef bone powder and dog bone powder, not autogenous, did not influence bone production critically. In two dogs, bone bridged the gap at four months but the result was invalid because, in both, the epiphyses had not closed.

#### CONCLUSIONS

1. The seeding of rat and rabbit muscle tissue with denatured bone powder is not sufficient to cause bone production. Whether or not the host muscle is injured in preparation appears to make no difference.
2. Collagen as an artificial matrix (denatured fascia or tendon) appears to resist vascularization and absorption, and bone matrix does not grow into or among its strands.
3. Lucite and nylon filaments appear to be inert bone matrix substitutes. They permit the penetration of the reparative bone matrix in and about the donor mass.
4. A clinical application of the use of bone matrix substitute is cited.

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#### DISCUSSION

ARTHUR G. DAVIS (Eric, Pa.): I am not fitted to go into the experimental side of Dr. Hudack's work critically. However, I have this interest, that from the purely clinical side, we are in a state of flux as to what constitutes callus formation. Dr. Hudack is attempting to bridge gaps, and apparently successfully, with inert material.

But, first of all, I must disclaim any first-hand knowledge of the experimental laboratory in the matter of callus formation. There is the necessity for the clinician, however, attempting to reconcile the clinical fact with the laboratory evidence. Dr. Hudack properly predicates his remarks on the fact that the nature of callus formation is unknown.

Being thus confronted with an inexplicable phenomenon permits me the privilege of choosing between schools of thought, the one I think the most logical. I prefer, therefore, to limit my discussion to this phase.

The new school, among whom the names of Dr. Clay Ray Murray and Dr. Stephen Hudack are significant, seems to be gaining ground. I find their viewpoint much closer to the clinical fact than that of the "osteoblastic theory," in spite of the ubiquitous but still mysterious osteoblast. Their work has been augmented lately by the addition to our knowledge of molecular structure, x-ray diffraction patterns, crystalline lattices and their self-propagation, the study of matrices simulating fibrin and collagen, the micellar brush heaps, the crystallite and linear theory of protoplasm and the readiness with which undifferentiated protoplasm can rearrange its molecular structure, depending upon the physical and chemical factors composing its immediate environment. All this tends to substantiate the earlier observations of these contributors.

The chronologic order of events in the gross seems to be supported by laboratory evidence, from the time of the injury and tissue death with its accompaniment of acid phase, the interval of clot, granulation tissue, capillary buds and anastomotic circulation between fragments completing the fibrous tissue phase. The temporary acid state, making available a high concentration of utilizable calcium phosphate from local structural bone, the agency of an adequate local circulation in changing from the acid to the alkaline side of the neutral point and its effect on activating phosphatase for subsequent utilization of calcium phosphate, seems altogether comparable to the magic effect of vitamin D in rickets.

The proof in the case of the antirachitic factor in the growth of bone is undeniable. The question of phosphatase or other enzymes liberated by cell death and their agency in initiating calcification in the undifferentiated matrix may be described as plausible and significant rather than as yet proved fact.

At this point, however, the laboratory leaves off abruptly with an amorphous semi-plastic mass of new building material which gradually takes form. This theoretical and fortuitously constructed brush heap then transforms itself by some magic into structural bone. Not only that, it also automatically compensates for transitory architectural redundancy. Where bone projects uselessly into soft parts, it disappears. Where there is not enough functional and structural integrity, more and stronger cortical structure makes its appearance always on the side of the maximum compression strain.

This latter phase seems explicable on the basis of the compression and tension members contained in



living architecture. How common the clinical experience of the transformation induced by converting shear strain into compression strain! One cannot escape from the omnipresence of compression. Shearing, compression and tension cannot be considered apart from the chemical reaction, whether it be in the gross or minute.

Recent evidence tends more and more to accent the importance of compression strain. Such evidence as that afforded by Plemister's work in converting a pseudarthrosis into a solid union by creating new conditions, new stimulation in a non-union area, plus compression strain—simply allowing the two fragments to metamorphose by compression the fibrous tissue and start a new calcifying process—is altogether similar to the Sehenitz osteotomy of the hip. Then we have also the new method of Dr. Eggers. I discussed Dr. Eggers' paper in Chicago, and you may be familiar with his work. He has invented a plate in which the bone fragments are secured only partly to the plate. There is a slot in the plate which allows the two fragments to approximate each other, his theory being that if the normal tension within the living chamber—and I think that we cannot lose sight of that because it is always there as part of the environment under which callus forms—if this rack, in which the two fragments are held, is allowed to slide and is not firmly fixed as it is in the Sherman or Murray type of fixation, the jamming of these two fragments then induces this compression strain. At any rate, Dr. Eggers' cases are working. I am not convinced enough to use it, and I am waiting for more evidence, but when we see something like a hundred cases of Dr. Egger's, I think we may be convinced again of the effect of compression strain.

Pressures induced by normal muscle tension all appear to be consistent with the modern conception of crystalline lattices and collagen matrices as agents to bone formation.

In the end, I want to say that I am very grateful to have had this chance of glimpsing Dr. Hudack's most recent work, and I have found the physicochemical conception much more in line with the clinical work that we do. Without knowing anything first hand about the laboratory but simply noting the experimental facts and modifying the method accordingly, in bone grafting large defects and non-unions the clinical facts seem to agree with the laboratory evidence. I would like to add this testimony to Dr. Hudack's work.

JOHN C. A. GERSTER (New York, N.Y.): I would like to ask Dr. Hudack if certain abnormal occur-

rences of bone would shed any additional light on the research he and his associates are doing? Occasionally, bone is seen in places where it has no business to be, for example, in the scar tissue of certain abdominal wounds. It is known that the autopsies on John B. Murphy and on Theodore Roosevelt showed bone formation in the atheromatous aortic plaques of those two outstanding examples and exponents of the strenuous life.

And lastly it has been known that bone has occurred between the two corpora cavernosa as reported by my father.\* The subject was a Frenchman who wore a corset. He was rather adipose, and when sitting on the edge of his chair, the lower edge of the corset impinged on the penis. Whether the constant trauma of this corset was causative we do not know. These are examples of bone occurring where it has no business to be and not near anything except connective tissue and calcium deposit.

STEPHEN S. HUDACK (New York, N.Y.): The frequency with which callus or bone deposit takes place in one site of a repairing fracture and not in another testifies to the fact that the intimate conditions of a very circumscribed nature are capable of controlling the deposition of bone.

The importance of Dr. Gerster's comment on the heterotropic bone formation again simply supports the concept that so-called specific osteoblasts are not necessary in the formation of this type of bone. There are no osteoblasts in epigastric scars. Inferentially, one is drawn to the hypothesis that the undifferentiated fibroblast which is present as a response to injury is capable of differentiating so that whatever materials are necessary biologically or physically for the production of bone at that particular site, if there is some factor which the living cell contributes—and I am confident that eventually we will learn that that is so—it does not have to be the so-called specialist osteoblast, but these cells may derive from the primitive cells which are present in response to injury in any region.

Of course, we do not know enough as yet about the concentration of phosphatase and other factors which appear to be necessary in the process of bone formation except that, for instance, in places like the kidney or bladder, in conjunction with fascial grafts and things like that. Bone can be produced where osteoblasts are not present.

I hope that in perhaps another fifty years, I can answer Dr. Gerster's question. Right now, I do not know.

\* GERSTER, A. G. Formation of bone in the human penis. *Ann. Surg.*, July, 1915.





# INJURIES TO THE HIP JOINT\*

## TRAUMATIC DISLOCATIONS INCURRED CHIEFLY IN JEEP ACCIDENTS IN WORLD WAR II

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THIS paper is the first of three communications concerned with the analysis of fifty-eight injuries of the hip joint treated definitively by a single surgeon in World War II. They were observed over a period of eighteen months (1944-1946) in twenty U. S. Army hospitals in the European Theater of Operations which admitted approximately 25,000 battle and non-battle casualties over the same period. Forty of the fifty-eight injuries were incurred in jeep accidents. Both before and after the institution of definitive treatment, the patients, as is inevitable in warfare, were treated by a variety of medical officers ranging from general practitioners briefly trained to handle military surgery to experienced surgeons whose views and practices concerning the management of such injuries varied widely.

The series of cases seems worth reporting on several counts: (1) It includes as many cases of this type of injury as would usually be admitted to a large urban hospital over a period of fifteen years. (2) Even though the absolute numbers are not large, the series provides sufficient clinical material for an evaluation of the current teachings and practice in respect to these injuries. (3) Because so many different medical officers participated in the treatment of these patients, the series is of historic interest and may fairly be considered an over-all picture of the management of injuries of the hip in World War II.

For convenience of analysis the fifty-eight cases have been divided into three groups: dislocations of the hip joint (fifteen cases), fractures of the acetabulum without dislocations (sixteen cases) and fracture-dislocations of the hip joint (twenty-seven cases). The dislocations serve as a control group for the fracture-dislocations. The fractures of the acetabulum serve as a control group for the injuries to the articular surfaces in the same group.

This first communication is an analysis of fifteen cases of dislocation of the hip joint

(Table 1) sustained chiefly in jeep accidents in France and Germany in both combat and non-combat circumstances in World War II. Follow-up reports have been obtained in as many instances as possible approximately two years after the injuries from letters and roentgenograms submitted by patients and their local physicians or from examinations reported by Army and Veterans Hospitals. The end results of the injuries as determined from these sources are compared with the end results of similar injuries as determined by the examination of patients at the Massachusetts General Hospital at various periods of time after the injury was sustained.

### MECHANISM OF INJURY

The exact mechanism of injury in the fourteen posterior and one anterior (obturator) dislocations which make up this series was frequently not possible to determine exactly. Circumstantial evidence, on the basis of the location of contusions, bruises and fractures in the ipsilateral extremity, suggested that all dislocations and certain types of fractures of the hip joint were produced by a forceful blow on the flexed knee or on the sole of the foot, transmitted through the extended knee, either alone or in combination with violent blows against the lower back and the lateral aspect of the hip. (Fig. 1.)

It was the impression of the military surgeons who participated in the management of these cases that severe injuries of the hip, which are so uncommon<sup>9,45</sup> in civilian life, were relatively more common in World War II because of the new types of mechanization and of violence which had been introduced. Other contributing factors were also operative. The excitement and recklessness of men at war can, as always, be invoked to explain a high incidence for all types of severe injuries. Age or, more correctly, youth also played a part. With the exception of a single patient who was fifty-one years of age,

\* From The University of Chicago, School of Medicine, Chicago, Ill.

all the patients in this series were between the ages of nineteen and thirty-three, the age group in which the incidence of traumatic dislocations of the hip is always highest.

More specifically, the circumstances of injury explain the nature of the injury. With few

highways which permitted and encouraged travel at a high rate of speed were responsible for many of the accidents which occurred in the European Theater of Operations.

All of these considerations, although valid, do not detract from the special fact that the

TABLE I  
DISLOCATIONS OF THE HIP JOINT IN MILITARY PERSONNEL

Case No.	Age	Other Injuries of Ipsilateral Extremity	X-ray	Traction (wk.)	Weight-bearing (mo.)	Two-year Follow-up
1	21	Contusion knee	No fracture	5	4	Mild pains
2	20	.....	Serration, posterior rim	6	Unknown	Mild pains
3	27	Contusion knee; dislocation patella	No fracture	5	3	No follow-up
4	27	Fracture inferior pole of patella; posterior dislocation of knee	No fracture	8	4	Mild pains
5	21	.....	No fracture	..	2	No follow-up
6	20	Lacerated wound knee	Serration, posterior rim	8	3	No symptoms
7	51	Fracture upper tibia, fibula and patella; posterior dislocation knee	Avulsion-chip fracture femur	12	6	No symptoms
8	33	Dislocation mid-tarsal	No fracture	8	4	Mild pains
9	20	.....	Avulsion-chip fracture femur	8	2	Night pain
10	25	.....	No fracture	6	Unknown	No follow-up
11	24	.....	Avulsion-chip fracture inferior rim	8	3	No follow-up
12	20	Lacerated wound knee	No fractures	4	4	No symptoms
13	20	.....	Undisplaced, incomplete rim fracture	8	3	No symptoms
14	21	.....	.....	8	3	No follow-up
15	19	Lacerated wound knee	Fracture pubic symphysis	5	Unknown	No follow-up

exceptions all the cases in this series occurred in automobile accidents, with the jeep, as already noted, responsible for most of the casualties. Although soldiers were constantly involved in accidents in tanks, aircraft, trucks and other types of mechanized vehicles, under conditions which seemed equally hazardous, dislocations of the hip were seldom the result. The U. S. Army Truck,  $\frac{1}{4}$  ton, more popularly called the "jeep" or the "peep," seems to possess special structural characteristics which put the soldier in a favorable anatomic position for the production of this special injury. The fact that this vehicle was the most commonly used in the U. S. Army cannot be overlooked as an explanation of the relatively high incidence of dislocations of the hip in Army experience. On the other hand, the impression was gained from communications with other surgeons working in other theaters of operations, who saw very few such injuries, that the concrete

jeep provided the exact conditions which experimental observations<sup>1,2,38</sup> have shown are necessary for the production of dislocations of the hip joint. (Fig. 2.) This vehicle, which during the war served admirably the purposes for which it was constructed, is similar in design to the old-fashioned wagon in that it has a minimum of protective framework and that passengers readily fall out of it. Its low seats necessarily require that the hips of the passenger be flexed more acutely than they are in other automobiles; it is while they are in an acute flexion that the head of the femur is in internal rotation, directly posteriorly, and disposed toward posterior dislocation. The instrument board or the back of the front seat is so close to the passenger's flexed knees that it is difficult to avoid the "dashboard" blow which has been described by so many writers as one of the classical patterns of modern injuries. The jeep itself, therefore, may be assumed to



FIG. 1. Typical posterior dislocation of hip as result of jeep accident. Note unequal length of leg, internal rotation of knee and adduction of hip. Note also severe bruises in prepatellar region on both sides.

be primarily responsible for the appearance of a large number of dislocations of the hip over a period of eighteen months when ordinarily it would take many years to collect a series of this size.

on the floorboard, or it may come from behind and be transmitted to the hip by the sacrum. Fractures of the rim of the acetabulum have been reported to follow blows on the trochanter; and central fractures, which ordinarily

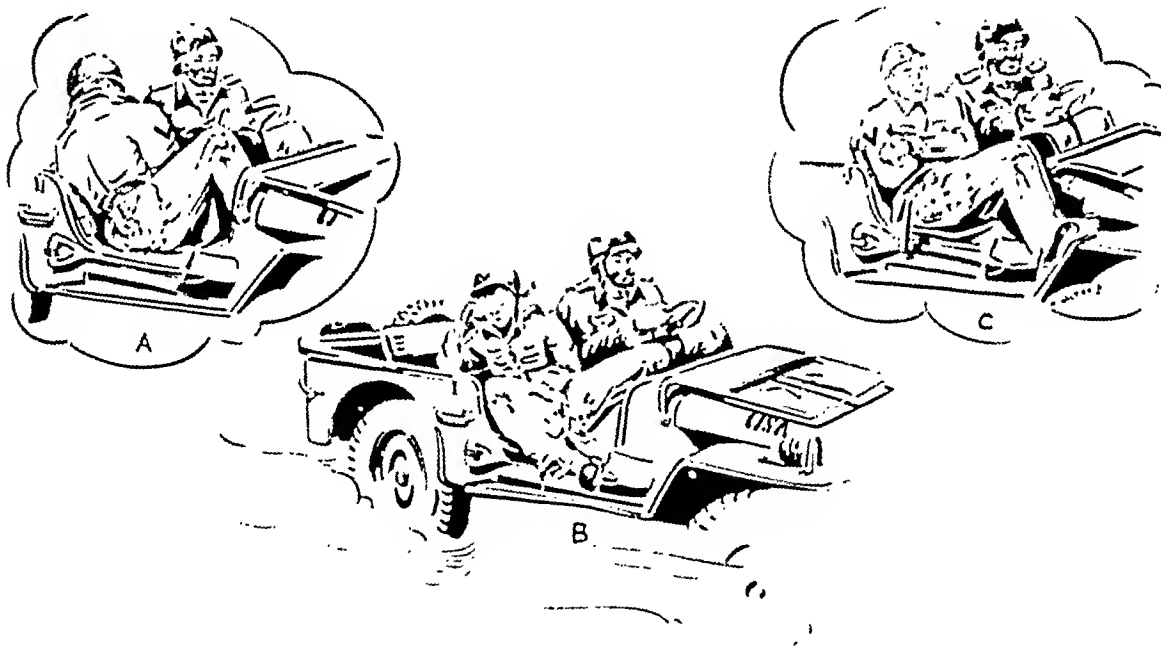


FIG. 2. Artist's interpretation of patients' own description of their positions and attitudes at the time of the injury. The accident was usually a head-on collision with resulting dislocations and fractures of the hip joint. A, inside-sitting position, the rider may have fallen out, striking the pelvis and incurring a fracture-dislocation or fracture. B, soldier sitting with legs abducted; in event of collision and dashboard blow on knee, may also have sustained fracture of the acetabulum or a fracture-dislocation. C, if rider was sitting with hips acutely flexed and adducted, the head of the femur may have dislocated with minimum or little damage to bony rim of the acetabulum.

Clinical and experimental evidence suggests that the nature of the injury in this type of accident is determined to some extent by the position of the joint at the time of injury. The blow may be received by the greater trochanter or be transmitted through the femur from the flexed knee on the dashboard or from the foot

are assumed to occur from this type of blow, have occurred from blows transmitted from the flexed knee or the extended leg when the hip was widely abducted. When the hip is adducted and flexed, as it is in a man riding in a jeep, perhaps with his legs crossed, the head may exit from the joint with minimum damage to

the bony structures, the result being an ordinary dislocation without a gross fracture.

#### TRAUMATIC LESIONS

The obvious traumatic lesions in these fifteen dislocations of the hip were chiefly injuries of the soft parts of the joint. Since in every case the method of treatment was closed manipulation, there were no opportunities to observe the lesions directly as there were at operations for fracture-dislocations. This is, of course, unfortunate in the sense that observations in fresh cases would supply knowledge concerning the differences in individual cases which determine the occurrence of avascular necrosis, another serious manifestation of this injury. A careful examination of the roentgenograms in these dislocations, however, in the light of the accumulated experience with experimental dislocations,<sup>1,2,38</sup> reveals certain details which seem significant and which may be relevant to this problem.

The roentgenologic location of avulsion chip fractures or serrations of the rim in three cases (Cases 2, 6 and 11) suggests that the capsule may have been torn at the acetabular attachment of the joint capsule. (Figs. 3 and 4.) In other cases (Cases 7 and 9), because of avulsion fractures in the posterior intertrochanteric region, the femoral attachment of the capsule was torn. (Figs. 5 and 6.) Allis<sup>1</sup> fully described both types of capsular lesions in his study of experimental dislocations. The possible relationship of the location of the capsular tear and the damage to the blood supply, particularly to the branches of the medial circumflex femoral artery which enter the hip joint in the intertrochanteric area posteriorly, merits further investigation.

Prereduction or postreduction roentgenograms also revealed other minor fractures which took the form of incomplete fissure fractures of the edge of the posterior acetabular rim. In fact, there were only eight cases among the forty-two dislocations and fracture-dislocations in the whole series of fifty-eight cases in which there was no evidence whatsoever of bone damage. Since roentgenograms of the hip joint usually show only gross defects, some damage to the rim and head of the femur may reasonably be assumed in every instance of dislocation. Observations at operations on fracture-dislocations demonstrate that some damage is usually sustained by the articular cartilage. Disloca-

tions without major fractures usually damage the soft parts and parietal capsule more extensively than do those which break the bony structure.

Dollinger's<sup>12</sup> description of the traumatic lesion in twelve instances of inveterate dislocation which was observed at operation is one of the most complete on record. Tears were observed in all the posterior muscles, including the quadratus femoris. A survey of the few autopsied cases<sup>2,8,24,46</sup> and some remarks about findings at operation on irreducible dislocations<sup>22,33,36,39,49,51</sup> in the older literature suggests that in these injuries the head of the femur most frequently escapes between the piriformis and obturator internus, tears the fragile gemelli muscles and comes to rest with the more durable obturator tendons stretched over and under the protruding neck of the femur. Damage to the intertrochanteric attachment of the posterior capsule at the insertion of these muscles, the point at which the largest part of the blood supply enters the hip, seems never to have been observed. Avulsion fractures repeatedly observed in this region in postreduction roentgenograms supply sound evidence that such damage occurs and should be searched for.

The position of the head of the femur, as determined by the position of the lower extremity, furnished the basis for the early classification of dislocations of the hip as well as for the clinical diagnosis during the pre-roentgen age. Cooper,<sup>8</sup> in 1844, listed five different types of traumatic dislocation of the hip; Malgaigne,<sup>27</sup> in 1855, suggested seven, namely, iliac, ischiatic, supracotyloid, subcotyloid, perineal, ischiopubic and iliopubic, named in counterclockwise order around the acetabulum. He also recognized mixed types such as complicated and complex. The advent of roentgenology made clear that many of these types were chiefly theoretic possibilities and that the most important consideration is whether the dislocated head is anterior or posterior to the acetabulum. Bigelow's postmortem studies<sup>2</sup> showed that the Y ligament is usually intact in posterior dislocations (his so-called regular dislocations). He depended upon this ligament to serve as a fulcrum for circumduction in the manipulations which he advocated.

When no fracture is present, the head of the femur probably does not displace farther than just over the rim of the acetabulum. This was



FIG. 3. Emergency roentgenogram of posterior dislocation of hip joint. Film is of average quality. In such films there was often no bone detail and fractures were not suspected (Case 11).

FIG. 4. Roentgenogram after manipulation and reduction of dislocation by Stimson's maneuver, showing avulsion-chip fracture, probably of interior posterior rim of acetabulum. The acetabular attachment of the joint capsule has presumably been torn away. Note improvement in quality of film.

its position in all fifteen cases in this series. A case reported by Kleinberg<sup>21</sup> suggests that the excursion of the head may be less than the length of the ligamentum teres. If the head escapes by way of the cotyloid notch, this ligament may not be torn, a possibility easily verified by a fresh anatomic preparation of a hip joint after circumcision of the capsule.

The single anterior dislocation in this series resembles those reported in recent literature.<sup>5,25,40</sup> The head of the femur rested opposite the obturator foramen but its position could not be determined by rectal examination.<sup>16</sup> Dislocation of the head into the scrotum and similar bizarre displacements are illustrations of Bigelow's irregular types<sup>2</sup> of dislocation. There were no such cases in this series. Sixty-two cases of bilateral dislocations of the hip, representing various types, have been reported in recent years but individually the lesions are the same as in ordinary cases.<sup>23,50</sup>

#### TREATMENT

**Emergency Measures.** Because of the striking clinical picture and the obvious deformity, most of these fifteen dislocations were promptly recognized in battalion aid stations and field hospitals. Occasionally, an attempt was made

to mobilize the extremity by the use of a Thomas splint. More often preventive treatment for shock was instituted and the leg was simply bandaged to the litter; or the patient protected himself against further trauma until the diagnosis was confirmed by roentgenology and the dislocation was reduced. Six of the patients had severe injuries of other parts of the ipsilateral extremity which also required immobilization.

**Reduction.** All fifteen dislocations were reduced, apparently without difficulty, by relatively inexperienced surgeons. While no definite statements appeared on the record as to the number of attempts or the length of time required to achieve the results, sodium pentothal alone was used in twelve of thirteen cases which suggests reasonably prompt success. In the fourteenth case the dislocation reduced spontaneously without anesthesia; this patient was in shock and all four extremities were injured. In the fifteenth case the first attempt at reduction was unsuccessful and a second surgeon later reduced the dislocation; pentothal anesthesia was employed for both manipulations.

Five dislocations were successfully reduced at the first attempt by Stimson's maneuver, which was also later employed in two other

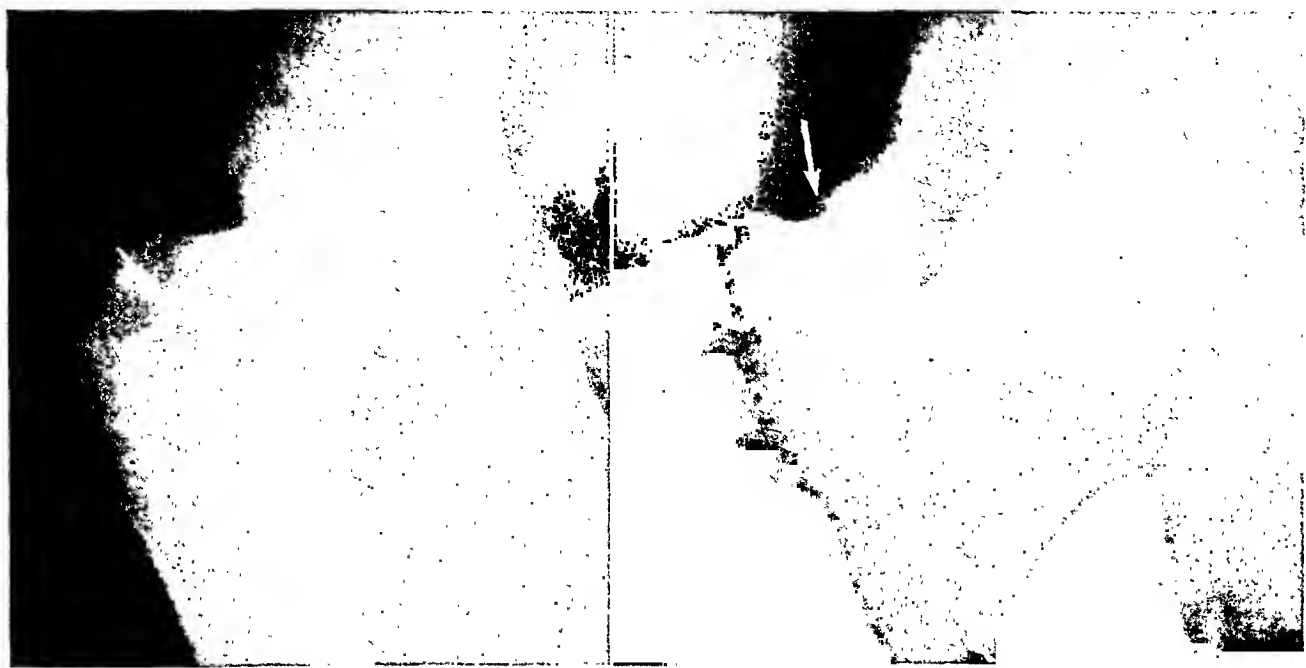


FIG. 5. Emergency roentgenogram of posterior dislocation, showing suspected fracture of femur (Case 7).

FIG. 6. Post-reduction roentgenogram, showing avulsion fracture of superior portion of intertrochanteric ridge, which is in the line of the femoral attachment of joint capsule posteriorly.

cases, after unsuccessful manipulation by the Bigelow circumduction method and the Allis supine method. Stimson's technic<sup>47</sup> was closely followed. Nothing was done until the muscles were fully relaxed. Then the thigh was slightly rocked to and fro which amounted to gentle internal and external rotation. In all the instances in which the method was used, the head of the femur promptly slid down into the acetabulum. The weight of the hanging limb plus a little downward pressure on the posterior upper tibia supplies the needed traction. The single anterior dislocation in this series was easily reduced, with the patient supine, by the reverse-circumduction method of Bigelow.

Reports in the older literature indicate that dislocations are easy for experienced surgeons to reduce by any method if there are no obstacles in the pathway of the displaced femoral head and if the acetabulum has not been distorted.<sup>2,10</sup> Ambroise Paré<sup>35</sup> and surgeons of early medical history leading up to the time of Sir Astley Cooper<sup>8</sup> and even later stretched the joint capsule and muscles and accomplished forcible reduction, without much difficulty in the majority of cases, by traction with the block and tackle. But strong traction has been regarded as unnecessary and even harmful since Bigelow emphasized the importance of flexing the hip to relax the Y ligament. After the joint has been properly flexed and muscular

relaxation has been obtained under anesthesia (spinal, if that type is preferred), reduction has frequently been achieved with gravity alone and has even been reported to occur spontaneously. Allis reported the successful use of the gravity method in cases in which he could not reduce the dislocation by any of the methods he usually employed and Bigelow also reported a successful reduction with gravity in the prone position. The patient was a twelve year old girl with whom he had failed six or seven times with the circumduction maneuver.

The Allis,<sup>1</sup> Bigelow,<sup>2</sup> and Stimson<sup>48</sup> methods, all described by American surgeons, are all effective in reducing dislocations of the hip in the majority of cases. Few of the many modifications of the Bigelow<sup>29</sup> and Allis methods<sup>3,11,34</sup> are generally known and most of them were therefore not tested in World War II. Stimson's method or one of its variations<sup>13</sup> is obviously the simplest and gentlest method of obtaining traction as many observers have testified.<sup>20,23,46</sup> The satisfactory results achieved with it in World War II suggest that inexperienced surgeons would always do well to start with Stimson's method. An experienced hip surgeon<sup>41</sup> would not use standard manipulations but would base his procedure on the clinical and roentgenologic findings in the special case.

*Immobilization.* One patient in this series was transported with the legs bound together in

a swath. Five, chiefly those who had suffered fractures and other injuries of distal joints of the same extremity, were evacuated in plaster of paris hip spicas. In the other nine cases complete recumbency was enforced for evacuation but immobilization was not employed.

When the patients were received at general hospitals at periods varying from a few hours to ten days after injury, they were treated in skin traction (bilateral Buek's extension or Russell's suspension) or by skeletal traction (by a Kirsehnner wire through the tibial tubercle) with 10 pounds' pull. Traction was employed arbitrarily as being the most logical form of treatment. There were no special Army directives for the management of unusual injuries such as these and there is also no uniform teaching on the subject.

Traction was employed for periods varying from four to eight weeks. The wide variation was not intentional but was due to irregularities in the evacuation schedule caused by the weather and the tactical situation in the European Theater of Operations. All patients were candidates for evacuation since they were considered to be in need of treatment for a year or longer at the least and were, therefore, ineligible for further duty in a combat area.

Six weeks was regarded as the optimum period of traction since the joint capsule and the ligaments require that period of time for complete healing. The rationale of treatment, in view of the complications which could arise from injury to vascular structures of the hip joint, was that maintenance of the circulation and healing of blood vessels would be aided by rest in traction.

The teaching on the subject, as already noted, is widely variable and the physician must formulate his own policies as to post-operative immobilization after traumatic dislocation of the hip. Equally experienced surgeons recommend that a hip spica be applied for two, three,<sup>43,52</sup> four<sup>23</sup> and eight weeks,<sup>6</sup> or that traction be applied for two, three,<sup>16,44</sup> or four weeks,<sup>7,17</sup> or that the patient be kept at rest in bed with no restriction of motion at all.<sup>14,26,31,32,37,44</sup> There is no evidence that the end results were any better when traction was employed for six weeks, as it was in this series, or that it modified convalescence at all. On the other hand, there is no basis for comparison of these cases with other cases since control studies on treatment and end results have ap-

parently never been published. There were no instances of avascular necrosis and degenerative arthritis among these fifteen dislocations but their absence may be only coincidental. These complications were observed in the cases of fracture-dislocations in this series and no claims can be made that their absence in this small group of simple dislocations had anything at all to do with treatment. The literature suggests that avascular necrosis is apparently almost as common in simple dislocations as in fracture-dislocations, although many reports do not mention the presence of associated fractures and end results do not seem to have been evaluated on that basis.

**Weight-bearing.** All patients were evacuated to the Zone of Interior with instructions not to put weight on the injured hip earlier than six months after injury unless they were specifically instructed to do so by a medical officer who had examined a recent roentgenogram. They were informed of possible complications of dislocations of the hip and were told categorically that weight-bearing might be detrimental to recovery and that crutches should be used for a period of six months at least. As might have been expected, either the patient's own restlessness or the advice of other medical officers encouraged weight-bearing as early as three months in about half of the cases. Only the patients with associated fractures of the knee or foot are known to have refrained from weight-bearing for six months or longer.

Again there is no control series of cases on which to formulate opinions as to the value of weight-bearing. It has been arbitrarily withheld, according to the literature, for periods ranging from four to six weeks up to six months. There is no evidence to suggest, either from the literature or from the fifteen cases in this series, that it is detrimental to recovery in the majority of patients or that it contributes to the development of complications. There is, however, some evidence in the literature to suggest that established complications as avascular necrosis, ossification of the joint capsule and degenerative arthritis are symptomatically aggravated by it. Restricted weight-bearing is generally believed to produce disuse atrophy of the base of the neck of the femur, which accentuates the density of the dead parts of the head and thereby aids in the early diagnosis of avascular necrosis.



FOLLOW-UP STUDIES

The value of the methods of treatment used in these fifteen consecutive cases of ordinary dislocations can be determined only by their end results; however, many writers do not believe the end results can be stated conclu-

of weight-bearing practiced in the military cases. Five of the nine patients in the military group and two of the seven patients in the civilian group complained of slight aches and pains in the joints at irregular intervals. The patients in both groups who did hard labor or farm work

TABLE II  
SELECTED TRAUMATIC DISLOCATIONS OF THE HIP JOINT AT MASSACHUSETTS GENERAL HOSPITAL, 1931-1947

No.	Age	Other Injuries of Ipsilateral Extremity	X-ray	Treatment	Follow-up
232707	11	Sciatic nerve contusion, temporary peroneal palsy	Posterior dislocation	Non-weight-bearing caliper splint 6 mo.	Normal hip at 7 yr.
13739	14	.....	Posterior dislocation	Crutches 3 mo.	Avascular necrosis and complete collapse of femoral head at 18 mo.
225358	18	.....	Posterior dislocation	Bed rest 8 wk.	Normal hip at 2 yr.
330426	22	Head injury; fracture shaft femur	Posterior dislocation hip fracture rim acetabulum	Reduction in Soutter apparatus; bed rest 6 mo.	Occasional mild joint pains; normal x-ray at 5 yr.
235958	28	.....	Anterior dislocation	Hip spica 3 wk.	Night pain and slight limitation of motion in joint at 5 yr.; normal x-ray
543012	35	.....	Anterior dislocation	Bed rest 3 wk.	Normal hip at 1 yr.
399281	22	.....	Posterior dislocation	Hip spica 2 wk.; crutches 6 wk.	Normal hip at 4 yr.

sively until five to ten years after injury to allow time for possible development of degenerative arthritis. A group of 370 traumatic dislocations, reported in the literature and reviewed for purposes of this study in the third paper of this series, shows that aseptic necrosis usually occurs within two years. As a matter of fact, very few cases have been followed for longer periods of time.

It was possible at the end of two years to locate only nine of the fifteen patients in this series. In order to compare the results achieved in these nine cases with results in patients with similar injuries who have been treated, as is usual in civilian practice by shorter periods of immobilization and early weight-bearing, seven cases were selected from the Fracture Service of the Massachusetts General Hospital. (Table II.) These patients were examined at intervals of time varying from one to seven years.

A comparative analysis of the two groups of patients shows the same results. There were no immediate benefits derived from the extended period in traction and the extended restriction

were uncomfortable when they had to lift heavy objects. Four of the patients in both groups, during the first few months of weight-bearing, complained of pains in the joint in rainy weather, when they were climbing stairs and when engaged in sports, but they were free of these symptoms at the end of two years. One patient had night pain but the roentgenogram, being entirely negative, showed no cause for it. One patient, a fourteen year old boy, had developed avascular necrosis of the head of the femur before the end of one year. The poor result in this case must be disqualified somewhat because necrosis occurs more commonly in dislocations in patients in the adolescent age group. There was no evidence of degenerative arthritis in three other civilian patients examined from five to seven years after injury.

SUMMARY AND CONCLUSIONS

1. This paper is concerned with an analysis of fifteen dislocations of the hip, without major fractures of the head of the femur or acetab-

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ulum which occurred in the European Theater of Operations chiefly as the result of jeep accidents. Fourteen were posterior and one anterior.

the hip joint treated at the Massachusetts General Hospital.

2. Reduction was accomplished without difficulty in all cases by relatively inexperienced surgeons. Stimson's maneuver (prone position-gravity method) was uniformly successful in this series and is recommended for the first attempt at reduction of posterior dislocations.

3. Avulsion chip fractures, which were usually unrecognized in emergency films, were observed at the femoral and acetabular attachments of the joint capsule in technically perfect postreduction roentgenograms. The femoral fractures may indicate injury to the blood supply of the joint, particularly the intertrochanteric branches of the medial circumflex femoral artery, and patients in whom they are observed may require closer observation for late complications.

4. Nine military patients who could be located at the end of two years were compared with seven civilian patients treated on the fracture service of the Massachusetts General Hospital and examined from one to seven years after injury. Prolonged traction and longer restriction of weight-bearing in the military cases produced approximately the same results as shorter periods of immobilization and early crutch-walking in civilian cases. Although only tentative conclusions are possible from two-year end results, the uniformly good results in all except one patient at this time do not encourage restriction of weight-bearing as a routine measure beyond six to eight weeks, the period with which the joint capsule might be expected to heal. Close observation, protected weight-bearing and perhaps traction and bed rest at home might be advisable in individual cases as soon as roentgenograms suggest avascular necrosis or if there are persistent signs of joint irritation, muscle spasm and limitation of motion. A routine policy of restriction from weight-bearing in order to obtain early diagnosis of avascular necrosis was impossible to enforce in healthy young men.

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## DISCUSSION

HENRY H. RITTER (New York, N. Y.): I am very grateful to have had the privilege of listening to Dr. Urist's paper and enter into discussion of it. I regret that I did not have his paper before me when I was asked to discuss it. However, there is not very much to add to what he has said except to emphasize some of the points he has already brought out.

I do not believe that I have seen in the past twenty years the number of cases of dislocation of the hip that Dr. Urist has seen in a very short period of time. In our series of cases, we have seen no anterior dislocations and I do not know whether or not he saw any. None of his radiographs presented today showed any anterior dislocation.

The majority of cases that we have seen were central dislocations. We had a few posterior dislocations due to dashboard accidents and some due to falls from a height.

I think it is well to bear in mind that at no time does one-half of the head of the femur articulate with the acetabulum, that when the hip is flexed less of the head articulates with the acetabulum and, when the hip is flexed and the limb adducted, the head is relatively unprotected by the acetabulum and rests upon the posterior capsule of the joint. I believe that explains readily the dashboard dislocations and I think it explains, too, that when the hip is flexed and the limb is adducted dislocations usually take place without a fracture of the rim of the acetabulum; whereas if the hip is flexed and the limb not adducted, a fracture of the acetabulum is associated with the dislocation.

Again, I want to thank Dr. Urist. I want to call attention to just one more fact. We have had some trouble with aseptic necrosis and destructive arthritis of the hip and we are trying something new. We cannot pass comment on it yet as it is too soon to say but we have been using procaine intravenously and we believe that we are having less muscle spasm and are able to get greater motion in these hip joints

without pain. No definite claims are made for intravenous procaine at this time.

THOMAS B. QUIGLEY (Boston, Mass.): It was my privilege to be associated with Dr. Urist during the first part of this work which you have heard.

These injuries, although common in military service, are not too common, as he has pointed out, in civilian life. However, they do occur and I am going to show you slides illustrating one case which occurred last December.

As you have seen, the only photograph of the hip joint exposed at operation that Dr. Urist was able to obtain was one which I took with an inexpensive camera. Our facilities were not very good in the situation in which we were placed. This civilian case, however, gave us an opportunity to take some color photographs of the operative approach.\*

HENRY C. MARBLE (Boston, Mass.): This is an interesting problem and it has been given to you in an interesting way. Dislocations of the hip in the old days must have been common. For the life of me, I do not know why because the problem of deceleration and fast-moving vehicles was not the same.

In the old operating room at the Massachusetts General Hospital, we still have the block-and-tackle holds in the roof and the block-and-tackle holds in the floor where these patients were strapped down and turn-buckles and block-and-tackles attached and the dislocation was then torn into place. They must have been common.

Then, somewhat later, some of the older surgeons, particularly Bigelow and Allis, showed how these dislocations might be reduced by simple manipulation. Thereafter, in my house officer days, a dislocation of the hip was the prerogative of the senior surgeon; he always came down and there was a great ceremony of getting the patient ready. Then the senior surgeon, with considerable theatricals, took hold of the leg and everybody stood by and, after practicing a little shadow-boxing, he deftly and neatly put the hip back into place, and everybody bowed and the senior surgeon was then driven home in his carriage. That was the common procedure.

Once in a while, the senior surgeon, after his shadow-boxing and after his deft maneuvers, had not reduced the fracture. He then took his coat off and tackled it again and the patient was put under more adequate anesthesia. It was common practice to curse the anesthetist because he had not given you sufficient relaxation. He then tried again and again. And so we learned that there were two kinds of dislocation of the hip: the hip that went in easily and the hip that went in hard; and we discovered that the hips that went in easily did pretty well and the hips that went in hard did not do so well.

\* Dr. Quigley showed a number of illustrations and explained each.

Now, Dr. Urist has come and told you in a word what happens and why we had certain hips that did not reduce easily. They were the fracture cases that he has shown. When Dr. Urist first told me about this, I said: "But I didn't devise it, it has been told me all of my medical life. Did the hip go in easily?" and he looked at me and said, "No, nobody could get it in." That was the answer. That lip of acetabulum was like the wedge in the door and not until that was removed, as you all heard—and I did not see a single person asleep—you learned that the way to put that wedge back in place is by the proper approach.

For us from Boston to talk about the posterior approach, I admit, is almost heresy; but as you see from what Dr. Urist tells you it is the only proper approach for fractures of the posterior lip of the acetabulum. Dr. Urist has looked up for me some of the cases which we have had.

We talk about dislocations of the hip very glibly. Since 1931, we have found the amazing number of seven cases on which we could get end results.

He finds that those seven cases that were in civilian practice, in general, have done well. Six of them did very well. The patients, the youngest eleven and the oldest thirty-five, were all young adults. They had minimal bed rest after dislocation. They were weight-bearing in from four to six or eight weeks, and of the seven, six had good hips. The x-rays showed no degeneration. Only one of the seven patients had avascular necrosis.

HOMER H. STRYKER (Kalamazoo, Mich.): I think just a word ought to be mentioned about the orthopedic problem that follows many of these cases, namely, sterile necrosis.

This happens in a certain percentage of dislocations without fracture or in some of those with fracture. I think if any of you have tried to fuse these by the intra-articular method, while there is still sterile necrosis, you are apt to meet with disaster. I think Sir Watson-Jones has mentioned that. I think you either have to wait a period of about two years until the head has revascularized or else do an extra-articular fusion.

I have had pretty good luck with these by taking pretty large slabs from the external plate of the ilium and fusing it to the greater trochanter, ignoring the head and neck pretty much altogether. Or I suppose the Brittain type of arthrodesis could be used. But these are fractures that occur in young men and as soon as sterile necrosis takes place, I think fusion is the answer. The necrosis must be kept in mind when doing this fusion.

MARSHALL R. URIST (closing): I wish to thank everybody for the very kind discussion and to add a few remarks. In reply to Dr. Ritter I can report that we had one anterior dislocation, the obturator type, and it was incurred presumably by forceful abduction of both hips. This dislocation was easily

reduced by the reversing of the circumduction maneuver of Bigelow.

Dr. Quigley's patient was the only postwar civilian fracture-dislocation that we have observed under treatment. An extensive fracture with distortion of the acetabulum prevented the reduction by closed methods. At open operation as soon as the main fragments were disengaged, the head of the femur fell forward into its normal position in the joint. Dr. Quigley was then able to fortify the reduction with internal fixation of a posterior rim fragment and get a beautiful picture of the repair by x-ray.

Although by these somewhat spectacular operations we have given our patients a functional hip joint within six months, we do not know what is in store for them in years to come. A five-year follow-up is to be desired. How many and which types will develop degenerative arthritis is yet to be determined. It is consoling, however, to find that in 370 cases reported in the literature, the disastrous complication of avascular necrosis occurred within eighteen months of the time of the injury. Hence we assume from two-year follow-up reports that we know the result with respect to this problem in thirty-eight cases.

Dr. Marble reviewed the problems of treatment with me last winter while the results were coming in and kindly offered many helpful suggestions. His experiences closely resemble those which are

found in the older American literature. The nineteenth century surgeons apparently knew much more about this injury than we do in modern times. I have studied their descriptions of autopsy and experimental necropsy specimens. We are, at this time when trauma is autopsied mainly by the medical examiner and rarely by the academic investigator, indebted to the pioneer surgeons for the only information on record about the nature of the traumatic lesion.

Dr. Stryker, who quoted Watson-Jones, presents a point of variance from our views in which he believes that these patients should not have an intra-articular hip fusion until we know whether avascular necrosis will occur. We found that this complication is not so common as to be a deterrent factor in early treatment. We are inclined to think that the rich blood supply of the ilium can be transmitted to the avascular head, thereby possibly cancelling the effects of the necrosis and perhaps even saving leg length. After all, every bone graft is an area of avascular necrosis. For those reasons and many experiences in which we have observed the surgeon completely denude the head of the femur, excise the joint capsul and readily obtain fusion, I would favor early erosion of the joint for irreducible dislocations with extensive comminuted fractures of the acetabulum in active young men. In suitable cases an arthroplasty can be done at a later time if joint motion is required by the individual patient.



# JOINT MOBILIZING OPERATIONS ON THE HIP, KNEE AND SHOULDER FOR COMPLICATIONS FOLLOWING TRAUMA

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**F**RACTURES into a joint are regularly followed by degeneration of the joint cartilage. After a variable period, such a joint becomes the seat of a presenile degenerative osteoarthritis, the pathologic findings of which are indistinguishable from those of other types of degenerative joint disease. Indeed, there are certain instances of degenerative joint disease localized to a single joint that have a clear-cut antecedent history of either single or repeated minor trauma without osseous fracture. Example of degenerative joint disease following trauma, with or without fracture, are best known in the hip joint where the aseptic changes in the femoral head, and consequently in the overlying articular cartilage, follow with a certain regularity in cases of fracture of the femoral neck and dislocation of the hip. Less well known is the degenerative arthritis of the hip joint following acetabular fracture and following single or multiple severe trauma to the hip region. In groups of cases of degenerative arthritis of the hip, in which antecedent histories and roentgenograms were available, many revealed a definite causative factor, often trauma, (Plewes, 126 of 242 cases, 52 per cent; Harmon, 37 of 94 cases, 39.4 per cent).

In the series of cases of hip joint arthritis herein reported, twenty-two of thirty-five cases (62.8 per cent), trauma with or without definite fracture was the likely precipitating cause of degenerative arthritis. Little is known about the exact incidence of degenerative arthritis of the hip joint. Boyd and George reported an incidence of 33.6 per cent aseptic necrosis (41 of 122 cases) following within one to two years after union in transcervical fracture of the femur; 14.6 per cent of the whole series had "severe arthritic" change. Pfab stated that 8.3 per cent of twenty-four cases of uncomplicated hip joint dislocation developed aseptic necrosis of the femoral head.

In the other major joints, chondromalacia of the patella and marginal fractures are known to be definitely related to trauma, but the se-

quence of events is not clear. Chronic trauma, such as often repeated injury of occupations as seen in the shoulders of baseball pitchers and glass blowers, can also precede degenerative arthritis of that joint. The results from surgical treatment of instances of all these

TABLE I  
SUMMARY OF RESULTS FROM HIP MOBILIZING OPERATIONS  
IN UNILATERAL DEGENERATIVE HIP DISEASE  
FOLLOWING TRAUMA

	No. of Cases	Good	Fair	Poor*
Results from operating upon femoral head—thin plastic cups				
1. Degenerative arthritis following fracture.....	6	4	1	1
2. Degenerative arthritis following epiphysiolysis.....	4	3	0	1
3. Degenerative arthritis following trauma without initial demonstrable fracture.....	6	3	2	1
4. Aseptic necrosis of femoral head following dislocation of hip.....	2	1	1	0
5. Ankylosed hips (unilateral) following pyogenic arthritis of hip complicating compound injuries.....	3	0	0	3
Results from operating upon acetabulum— $\frac{3}{8}$ inch plastic cups turned from solid plastic all post-traumatic cases.....	8	7	1	0
Exostectomy upon femoral head and acetabulum without using interposition material. ....	6	2	3	1†

\* Two poor results were observed following fracture of the cups in the three first groups.

† Chief clinical results in this group were increase in motion with lessened pain.

conditions will be presented in this paper. Palliative and conservative treatment will not be considered, but the results from operations designed to decrease pain and secure additional motion in the hip, knee and shoulder joints will be described. For the hip, end results will be presented for cup arthroplasty and from excision of exostoses from acetabulum and femoral head. For the knee, results will be given for a modification of the Magnuson joint débridement operation. For the shoulder, results for partial resection of the humeral head and for removal of posterior glenoidal exostoses

in selected cases will be given. It should not be assumed that the operations described in this paper are applicable to all cases of degenerative arthritis of the joints in question or that they replace arthrodesis. Indeed, in the weight-bearing joints, the hip and knee, especially the

pyogenic infection of the hip, tuberculosis and rheumatoid spondylitis, show on the remaining forty-eight hips that 64.9 per cent were good and very good results, 20.8 per cent fair results and 14.6 per cent poor results. Harmon, in a previous report, gave 71.4 per cent good

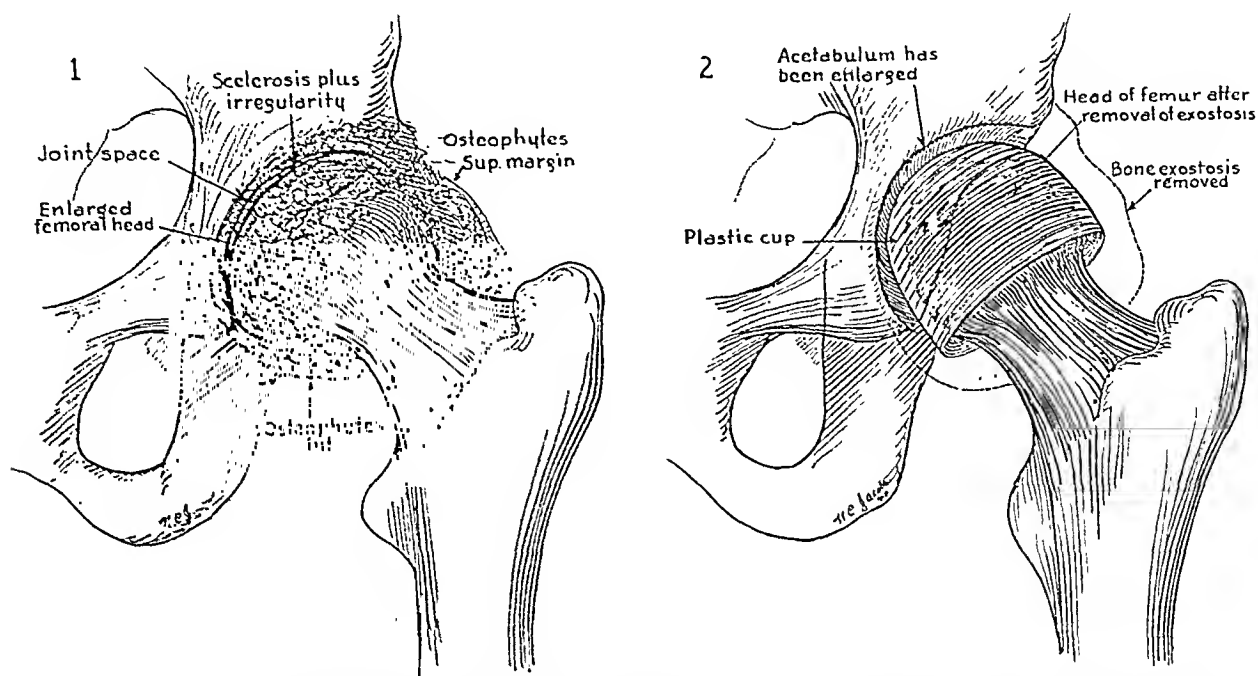


FIG. 1. Diagram illustrating hip arthroplasty by enlargement of the acetabulum when a plastic cup is fitted to the femoral head with minimal shaping of the femoral head. The clear space in the postoperative diagram represents the roentgen transparent "joint space" filled by the acrylic cup.

hip, the selection of a patient for a joint mobilizing operation should be made on the criteria of age, temperament, occupation and desire for the procedure after the postoperative treatment and expectation have been explained. Arthrodesis still remains the method of choice in advanced degenerative arthritis, especially when the subject must be certain of a painless joint that will serve him without fail in such occupations as laboring, farming, etc.

#### THE HIP

*Summary of Results from the Literature.* There are only three articles in the surgical literature which present a sufficient number of end results from cup arthroplasty on a single movable hip to warrant quotation for statistical purposes. Bickel, Ghormley et al., reporting on eighty-eight cases not fully segregated according to diagnosis, stated that 40.9 per cent were good, 28.4 per cent fair and 30.7 per cent poor. Badgley's statistics, corrected by removing cases of gonorrheal arthritis,

and very good results on twenty-one hips and 14.3 per cent fair results.

The criteria for the grading of the end results were the same as those utilized by Bickel, Ghormley et al. and are based on function, relief of pain and mobility. "Very good" is essentially a normal hip with a range of motion of at least 90 degrees flexion, a variable amount of abduction-adduction and a painless hip allowing full weight-bearing. "Good" signifies patients who had little or no pain, occasionally utilized a cane, had a variable degree of abduction-adduction, but who presented a minimal disability made worse by excessive use of the hip and by weather changes. "Fair" is utilized to indicate improvement over the preoperative status, a variable amount of minor disability and pain but tests of passive motion indicating only a fair amount. These patients often had a fair amount of pain on excessive use and could not use the hip for prolonged and strenuous activity. "Poor" indicates either sufficient pain to render the person definitely disabled and was often accompanied by poor passive motion.





FIG. 2. Roentgenograms at a ten-year interval illustrating the pathogenesis of degenerative osteoarthritis following single severe trauma without demonstrable fracture. A, the changes are subchondral sclerosis over the entire acetabulum with thickening of the mesial osseous acetabular wall, slight diminution of the joint space, especially in the weight-bearing portion of the joint, and the development of adductor and superior head-neck osteophytes. B, ten years later, the femoral head has been pushed out further laterally by proliferation of the mesial acetabular wall and by enlargement of osteophytes on the inferior head sector. The joint space has disappeared in the weight-bearing portion of the joint and the superior margin of the femoral head has become continuous with the trochanter by filling of the neck surface by osteophytic new bone. In addition, there are extensive degenerative changes in the femoral head, microscopic sections from which show both infarcted osseous islands and endosteal proliferative changes to produce dense bone.

In the author's first series, part of which is also quoted in this paper, a patient originally rated as "poor" was often given a good or very good result by removal of the cup when a fracture occurred in a plastic cup or cup removal was performed for continued pain two years or more after the operation. This was also Badgley's experience. This fact is not taken into consideration in Table 1, as the results recorded there are as resulting from the cup insertion and not influenced by a secondary operation.

Both in Badgley's report and in our previous end result report, the results were found to be unsuitable in arthroplasty following previous pyogenic infection of the hip. In five arthroplasties for osseous ankylosis following healed septic hips, we had but a single (20 per cent) good result. In a similar number of cases, Badgley reported four (80 per cent) fair results and one (20 per cent) poor result. Bone altered by previous infection does not appear to withstand weight-bearing following hip arthroplasty since the cause for failure was late and gradual collapse of the head-neck stump.

Magnuson believed that all of the eleven hips upon which he performed joint débridement were improved, but the criteria of improvement and the time of the evaluation were not stated.

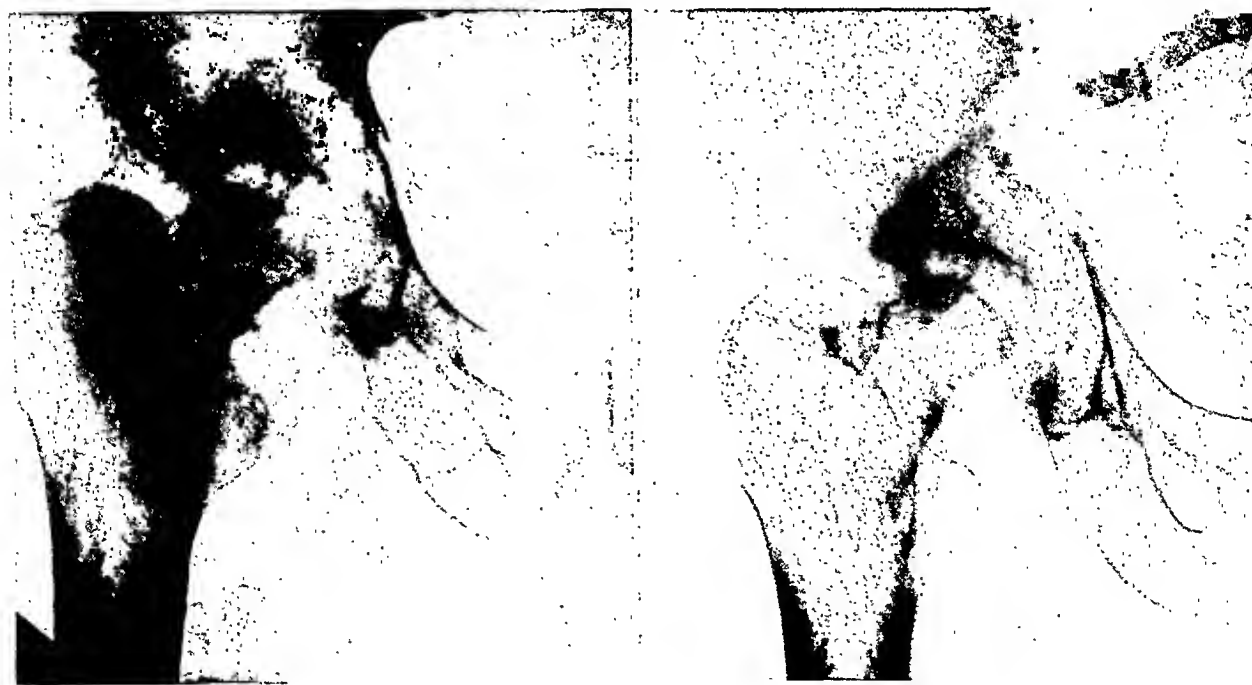
*Operative Technic.* The detailed operative technic (Fig. 1) for arthroplasty of the hip will not be repeated here, as it has already been given in the articles by Smith-Petersen, Harmon and Badgley. In the presence of a movable hip, we have always believed that the approach should be chiefly femoral, with a minimum of stripping and detachment of muscles from the anterior and lateral ilium. It is only absolutely necessary to divide or strip the tensor fascia femoris to expose the entire hip joint. Providing the subject is obese or stocky, detachment and downward reflection of the sartorius and the tendinous head of the rectus femoris will facilitate exposure. It is important clearly to expose the anterior, superior and adductor-inferior portions of the acetabulum, in order to remove accurately osteophytes and to judge the subsequent fit and motions of the cup in relation to the reconstructed femoral head and



A

B

FIG. 3. Roentgenograms over a ten-year period in a patient with degenerative arthritis of the hip following acetabular fracture. A and B are preoperative; A, one year after fracture; B, five years after fracture. Note further sclerosis of the femoral head and thickening of the mesial acetabular wall both into the acetabulum and on the pelvic side.



C

D

FIG. 3. C and D are postoperative, the "joint space" being occupied by an acrylic cup. C, one year after operation; D, four years postoperatively. Note surface sclerosis of the femoral head denoting satisfactory response to weight-bearing.

acetabulum. Minimal operating is done on the posterior acetabulum, but inspection and removal of osteophytes from the posterior femoral head, accomplished by manipulation after the head is dislocated, is quite important. It has been this author's conclusion, based on long term follow-up of the first series of cases

that there should be minimal removal of osteophytes from the femoral head consistent with securing a perfectly rounded femoral head from which secondary and tertiary circumferences have been eliminated (Figs. 4 and 6) and that there should be no operating that might damage the reflected capsule on the

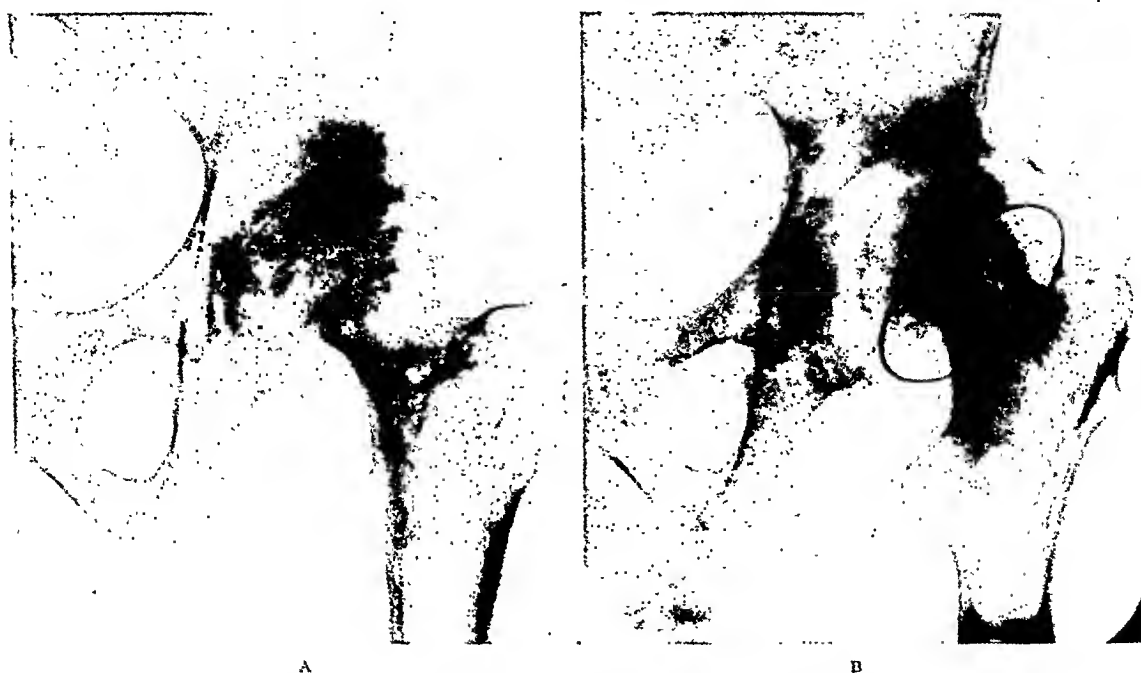


FIG. 4. Preoperative (A) and one year following operation (B) for degenerative arthritis following single trauma. Here, in addition to actual enlargement of the femoral head and cartilage degeneration in the joint, there is massive and extensive proliferation of the acetabular margins. This confers an impression of diffuse, intense sclerosis to both femoral head and acetabular margins. At operation, about seven-eighths of the normal extra-acetabular portion of the femoral head was covered by a sheet of acetabular new bone, especially from the anterior and superior acetabular margins. Note in (B), the postoperative view, that the osseous texture of the femoral head is clear since the acetabular new bone had been removed.

femoral neck. If radical bone removal is necessary to secure the aim of a loose fit of head within the cup and cup within the acetabulum, this should be done by enlarging the acetabulum. Since the newer plastic cups are  $\frac{3}{16}$  inch thick, this means more radical removal of bone when these cups are used. In a few cases (e.g., Figure 5, a case of aseptic insular necrosis with marked osteophyte formation in a young subject), we have utilized Vitallium cups with which acetabular reaming is minimal. In performing cup arthroplasty, the surgeon should have available a wide choice of sizes and styles of cups to secure the best result for each case under consideration. Preferred anesthesia is continuous fractional spinal with novocain crystals.

Since the end results on sixty-three hips in which thin methyl methacrylate cups molded from sheet plastic showed either fracture of the cup or excessive wearing in seven (11.1) per cent, we have revised the specifications for acrylic cups. The original cups were only  $\frac{1}{8}$  inch thick. The cups now in use have all been turned from solid blocks of a slightly harder acrylic resin, to the uniform thickness of

$\frac{3}{16}$  inch. We have had no fractured cups (thirty cases) since the newer type plastic cup has been in use (period of observation, six months to four years). Comparative tests on the two types of cups show that the forces required to rupture the cup from the inside and the external resistance to crush are approximately doubled in the newer cups. These latter values are of the magnitude of 400 to 800 pounds.

When the roentgenograms demonstrate slight to moderate narrowing of joint space, and inspection of the articular cartilage following osteophyte removal shows fairly good remaining cartilage with little or no pleat formation and little or no fibrillation, it is considered that this is a suitable case for the operation of exostectomy without dislocating the hip. Obviously, in instances of degenerative arthritis following trauma, the opportunity to carry out this latter type of operation is not frequently encountered. When the operation is performed, and there are complicated osteophyte systems on the posterior femoral head, these can be satisfactorily removed only in two stages, the second one of which is carried out

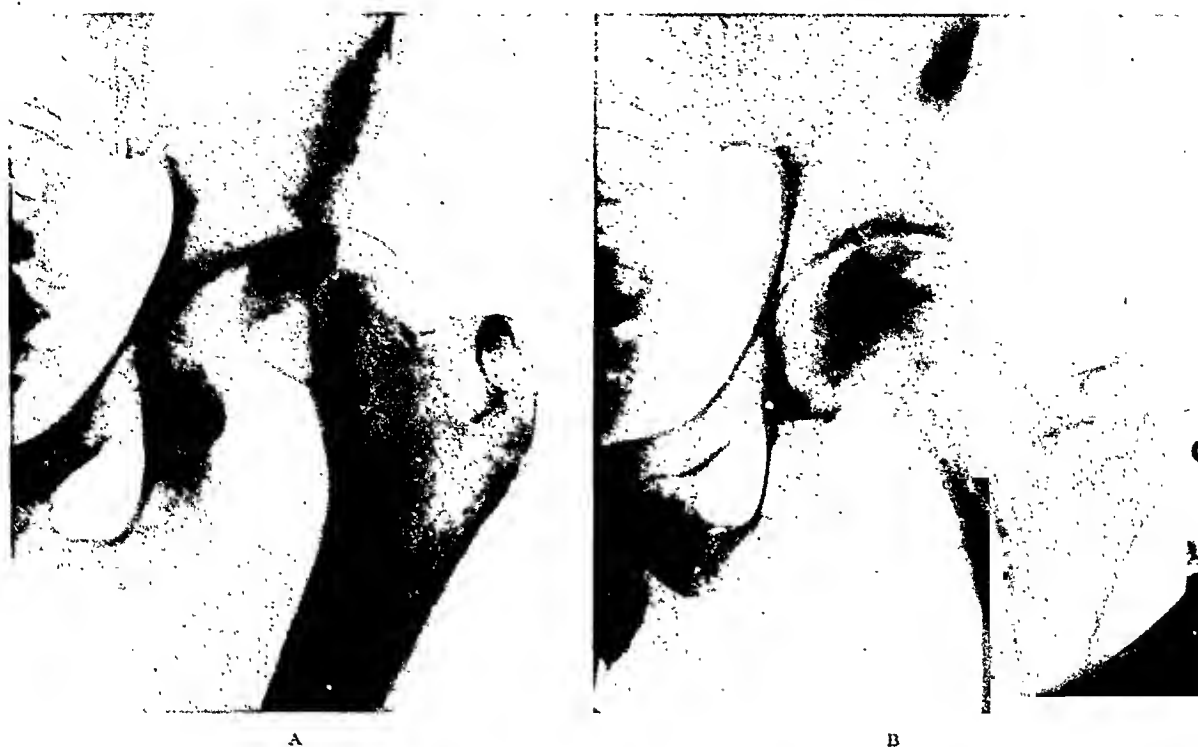


FIG. 5. Roentgenograms in a case of aseptic necrosis of the femoral head in a young man of twenty years following dislocation of the hip. A, shows the dislocation. B, a roentgenogram made one year later showing diffuse and complete aseptic necrosis of the femoral head except where slight substitution has started at the superior and inferior angles with slight collapse of the head from weight-bearing at the superior pole. At operation a ring of osteophytic new bone was present  $\frac{3}{8}$  inch in height at the head-neck margins.

through a posterior approach. It should be pointed out that the conventional anteroposterior roentgenograms of the hip do not reveal clearly the full extent of the osteophyte systems in degenerative arthritis. Often the femoral head will appear to be of mottled density when the appearance is conferred by overhanging osteophytes from the acetabular margins. (Fig. 4, 6 and 8.) If the femoral head is missing or fused into the acetabulum with the upper femur more or less normal, a modified Whitman operation utilizing a cup for interposition is carried out.

We have eliminated complicated postoperative fixation apparatus and complicated apparatus for exercise, as the complicated systems have no advantage over the simple regimen now employed. Postoperative immobilization is by Buck's extension of five to seven pounds. A wide internal rotating strap of adhesive tape is fixed to the thigh. A diagonally directed counterweighting of three or four pounds is placed on the rotator strap. The patient is allowed to shift from side to side and to be up on the back rest as soon as he can comfortably do so. Precautions are taken that he does not turn or allow the leg which has



FIG. 5. C, a roentgenogram eight months following operation. At operation no cartilage was removed from the femoral head and only a thin film was removed by reaming the acetabulum. The patient began almost full weight-bearing six or eight weeks after operation without knowledge or consent of the surgeon, now has almost a full range of motion, lacking only complete abduction and rotation and has had only minor pain since he began weight-bearing after operation.



FIG. 6. A and B, preoperative and postoperative roentgenograms in a fifty year old woman whose hip was the seat of degenerative osteoarthritis resulting from a congenitally inadequate acetabulum. The changes in the preoperative roentgenogram are proliferation of the intra-acetabular portion of the acetabular wall, diminution of the weight-bearing joint space and subchondral sclerosis in both femoral head and acetabulum. Postoperatively, the femoral head dislocated at three weeks and an acetabular shelf was built from the ilium at a second operation. The postoperative film was made four years later. The "joint space" is filled with the acrylic cup and the patient has no pain and near full motion.

been operated on to fall into adduction. He begins to get out of bed in the wheel chair and to start exercise in the physical therapy department at two and one-half weeks. Walking with crutches without weight-bearing on the operated leg is initiated at three and one-half weeks and slight but minimal weight-bearing, at eight weeks. Crutches are not discarded and full weight taken on the hip for four to eight months, depending upon the nature of the operation (degree of removal of weight-bearing bone and cartilage). The postoperative schedule is accelerated by one week in cases of exostectomy of the hip without dislocation. When the weight-bearing cartilage is not disturbed and no interposition substances used in this latter group, full weight-bearing is allowed with crutches or cane four to six weeks after the operation, depending on the patient's ability.

*Results from Hip Mobilizing Operations.* The results from thirty-five cases are summarized in groups as follows:

A: Five, six and seven year end results from hip arthroplasty with one-eighth inch molded cups of methyl methacrylate in twenty-one cases with a traumatic background, subdivided according to etiology:

1. Six cases of unilateral degenerative arthritis following fracture in the region of the hip, mostly acetabular fracture.
2. Four cases of degenerative arthritis following adolescent joint disease, presumably epiphysiolysis.
3. Six cases of unilateral degenerative arthritis of the hip, the clinical onset of which closely followed a major traumatic history. Roentgenograms either failed to reveal initial fracture in these cases or no roentgenograms were made, and the evidence now at hand tends to rule out original fracture.
4. Two cases of aseptic necrosis of the head of the femur complicating dislocation of the hip but without posterior marginal acetabular fracture. (Vitallium cup arthroplasty was performed in one case.)
5. Three cases of pyogenic arthritis of the hip with ankylosis, all being complications of compound injuries of the hip region.

In all of the above listed cases, the operative attack was primarily on the femoral head.

Only exostoses were removed from the acetabulum, which was smoothed but not enlarged.

B: One to three year end results from arthroplasty with methacrylate cups,  $\frac{3}{16}$  inch thickness, turned from solid plastic. The operation was primarily an enlargement of the acetabulum with minimal operating on the femoral head. All cases of unilateral degenerative arthritis followed trauma in the region of the hip, three of which complicated acetabular fracture.

C: Six cases of exostectomy of both femoral head and acetabular osteophytes without dislocation of the hip or use of interposition material. The end results are for variable periods, in one case, one year, in two cases, two years and in three cases, three years or more.

The results are summarized in Table 1. All results rated as "good" had stable hips with no or insignificant discomfort and had a gait which closely resembled normal. In about one-third of all good results, minimal discomfort resulted during weather changes and excessive use of the hip. The patients in all cases reported as good were well satisfied with the results. Roentgenograms in the first three groups taken at intervals over the five- to seven-year observation period showed a definite cause for the fair and poor results in nine of the ten cases in these two latter categories. The causes included gradual wearing away of the femoral head, further necrosis in this structure and fracture of the cup, this latter in two cases only. These changes in roentgenograms have been illustrated in a previous report. In a few cases, changes occurred in the femoral head with little or no symptoms occurring in the patient. (Fig. 3.)

It should be pointed out that the results have been uniformly good in the post-traumatic cases in which the major operative attack has been directed at the acetabulum (Table 1, item 6). So far, there have been no changes observed in the femoral heads in this group. It should also be pointed out that the results from exostectomy alone without the use of interposition material have turned out as palliative, chiefly consisting of considerable increase in motion. This latter result would be expected, because no change has been made in the contacted cartilage surfaces within the damaged joint. An insertion of a plastic cup has been done subsequently in two of these

six cases with good results (period of observation, one to two years).

#### THE KNEE

*Summary of Results from the Literature.* Bennett and Bauer long ago pointed out the rôle of poor adaptation of the patella to the femoral condyles in producing degenerative change in the knee joint in recurrent dislocation of the patella and in genu valgum and genu varum. They suggested that the remaining changes in the joint were secondary to changes in the patella and to trauma by the diseased patella. Berkheiser reported on excision of the patella alone in eleven cases of arthritis of the knee joint. His best results were secured in degenerative and in post-traumatic arthritis. Haggart operated on twenty patients. The majority were treated by total patellectomy combined with synovectomy. He reported nineteen of twenty cases "markedly improved" by the procedure. Young and Regan reported on total excision of the patella in fourteen cases of osteoarthritis of the knee. In seven, excellent results were secured, the criteria being no pain and at least 80 degrees active motion. Four good, two fair and one poor result were secured in the remainder. Magnuson reported "extremely satisfactory" results in over 100 cases of joint débridement on the knee.

*Operative Technic.* The technic of joint débridement will not be described here, as this has already been given in detail by Magnuson. We have modified Magnuson's operation by removing all or a portion of the patella, preferably the posterior two-thirds of it, for the reason that it has appeared that the extra bulk of the patella in degenerative arthritis also serves to fill up the interior of the joint. (Figs. 9, 10, and 11.) Briefly, after the joint is opened, exostoses are removed with an osteotome from around the periphery of the condylar margins. This includes exposure of the lateral and inferior condylar margins on both tibia and femur, and also the intercondylar region of the femur in the region of the cruciate ligaments. Articular cartilage is then shaved tangentially with either a sharp osteotome or a sharp knife. This is done to eliminate fibrillated cartilage and cartilage pleats. The semilunar cartilages, if loose and degenerated, are removed.

If there are large lateral projections on the patella, and the patella is quite dense, this structure is removed in its entirety. Usually,

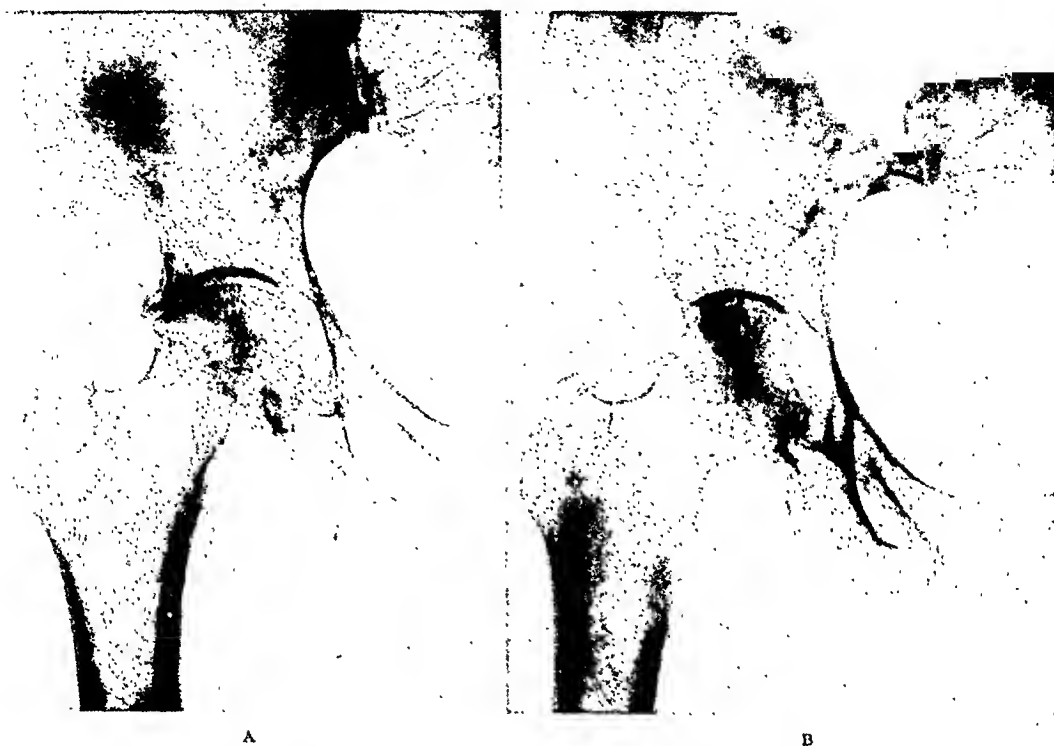


FIG. 7. Preoperative roentgenogram (A) in a case of early degenerative arthritis of the hip two years following single severe trauma. B, the immediate postoperative film, showing removal of the supra-acetabular osteophyte without dislocation of the femoral head.



FIG. 7. C, a film made two years following operation. This patient was fully relieved from symptoms and had a normal range of hip joint motion. Prior to operation rotation was limited 50 per cent and the patient had only 10 degrees' abduction.

however, the patella is merely thickened, the cartilage degenerated on its posterior surface, and the posterior surface of the patella marked

by other irregularities. A wide broad osteotome is used to divide the patella in a vertical direction into a posterior two-thirds or three-fourths, allowing the anterior remnant to remain in its attachment. After the posterior surface of the remnant is smoothed, a fat flap is cut from the infrapatellar fat pad, as shown in the illustration, and stitched into place with interrupted stitches. The treatment of the patella is facilitated by turning the posterior surface of the patella face-upward. This can be accomplished by grasping the medial surface of the patella with towel clips and everting it laterally over the finger or some other fixed structure. The patella is then inverted into the joint. The wound is closed by repairing the quadriceps expansion and the vastus medialis, preferably by interrupted non-absorbable stitches.

The postoperative care is immobilization in a lightly padded or skin-tight plaster cylinder for three to five days. When the cylinder is removed 2, 3, or 4 inch cotton elastic bandages are used to support the knee for the next week. Weight-bearing is begun on the second or third postoperative day, and the patient is out of bed in the wheel chair on the day following operation. The joint is near normal, and the patient returns to work in six to twelve weeks. Slow



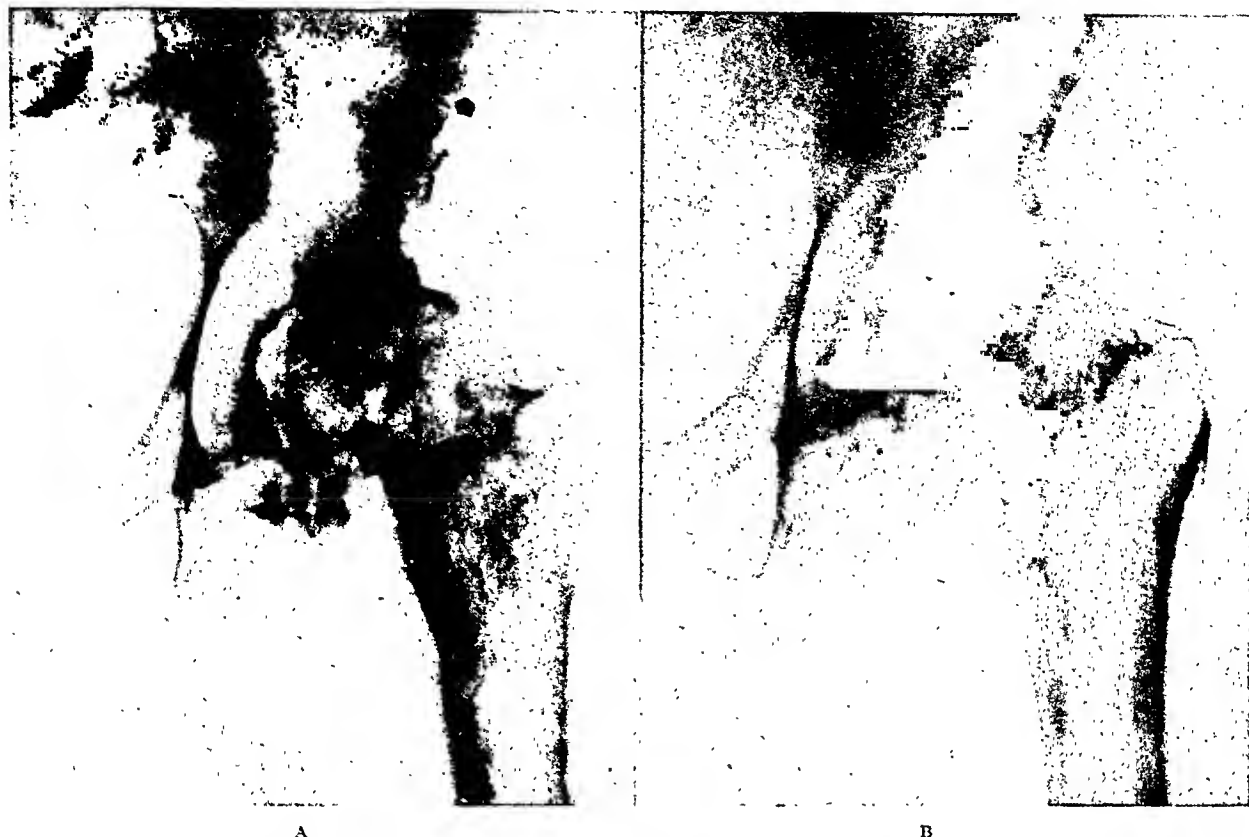


FIG. 8. A, preoperative and B and C, postoperative roentgenograms taken of a forty-six year old man whose hip was the seat of an extensive degenerative arthritis of unknown etiology and of twelve years' standing. Although not well shown in the preoperative film, the hip was the seat of one of the most extensive and intricate interlocking systems of osteophytes on both femoral head and acetabulum. The only change in the femoral head was subchondral sclerosis in the weight-bearing sector, as shown in C, after most of the osteophytes had been removed at a two-stage approach, one anterior and the other posterior. B, made after the anterior stage had been performed with removal of an estimated two-thirds of the total bulk of osteophytes.

improvement takes place for a year or more following operation. Any type of modern anesthesia is used with a preference for continuous or single spinal or some type of gas anesthesia.

*Results from Joint Mobilizing Operations on the Knee.* The results on thirty-seven cases are summarized below. The minimum follow-up period was two years, and the longest period of observation was eight years. The cases are grouped as follows:

A: Four cases in which patellaplasty only was performed. These were cases in relatively young persons who exhibited continued pain following a single trauma to the knee without fracture. The diagnosis was post-traumatic chondrodystrophy of the patella. Each of these patients had a normally functioning knee without pain and a full range of motion within four months following operation. The maximum follow-up period in these cases has varied from two to six years.

B: Patellaplasty with more or less complete joint débridement. No cases of bilateral



FIG. 8. C, made six months following the second stage. The patient was almost fully relieved of pain and motion was increased at the hip from 30 to 80 degrees flexion and rotation and abduction from nil to 50 per cent of normal. Interposition substance was not used because at operation the cartilage on the femoral head appeared of good thickness when viewed by manipulating the hip without dislocating it.

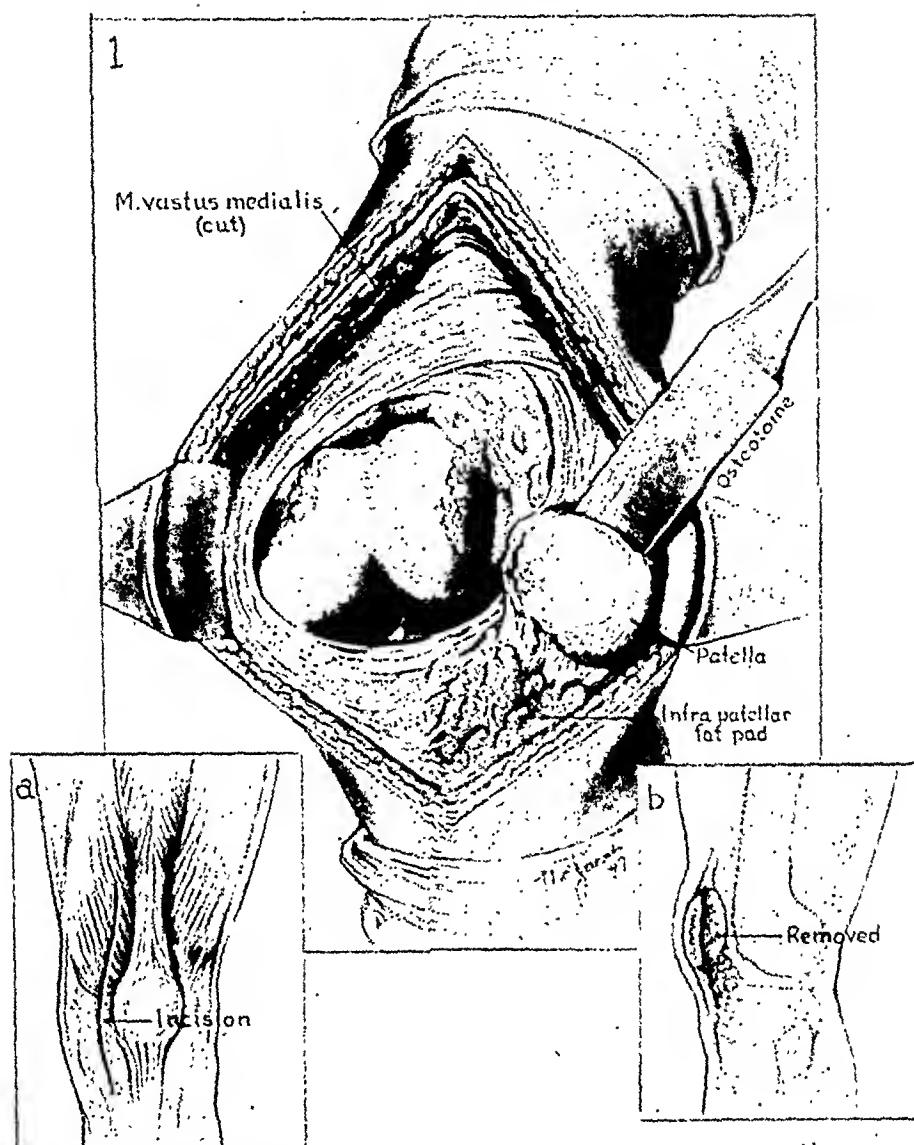


FIG. 9. Half tone drawing showing, *a*, the incision and *b*, the approximate amount of the posterior patella removed in the modification of the Magnuson joint débridement operation used in the cases herein reported. The main drawing, *1*, shows the method of sectioning the patella vertically with a broad osteotome.

degenerative arthritis or of degenerative arthritis occurring in obese women are included. Thirty-three cases in this group were subdivided as follows:

1. Single major traumatic history followed by continued pain but without discernible fracture, twelve cases.
2. Old fractures of the tibial and femoral condyles with original good reductions but with continued pain, four cases.
3. Degenerative arthritis of the knee of unknown causation, seventeen cases.

The results were good in thirty-one of the thirty-three cases in this group. The standard

of a good result was at least 130 degrees of active and passive motion and the presence of no or minimal pain. The results in the majority of these cases would be classed as spectacular with practically complete relief after months and years of chronic disability. The results were rated as fair in two cases. Both of these patients presented marked diffuse cartilage destruction throughout the joint and continued to have a certain amount of pain following operation. There was marked restriction in motion in these joints, the end results being only 30 degrees of active motion in one case and two-thirds of a normal range of motion in the other case. The

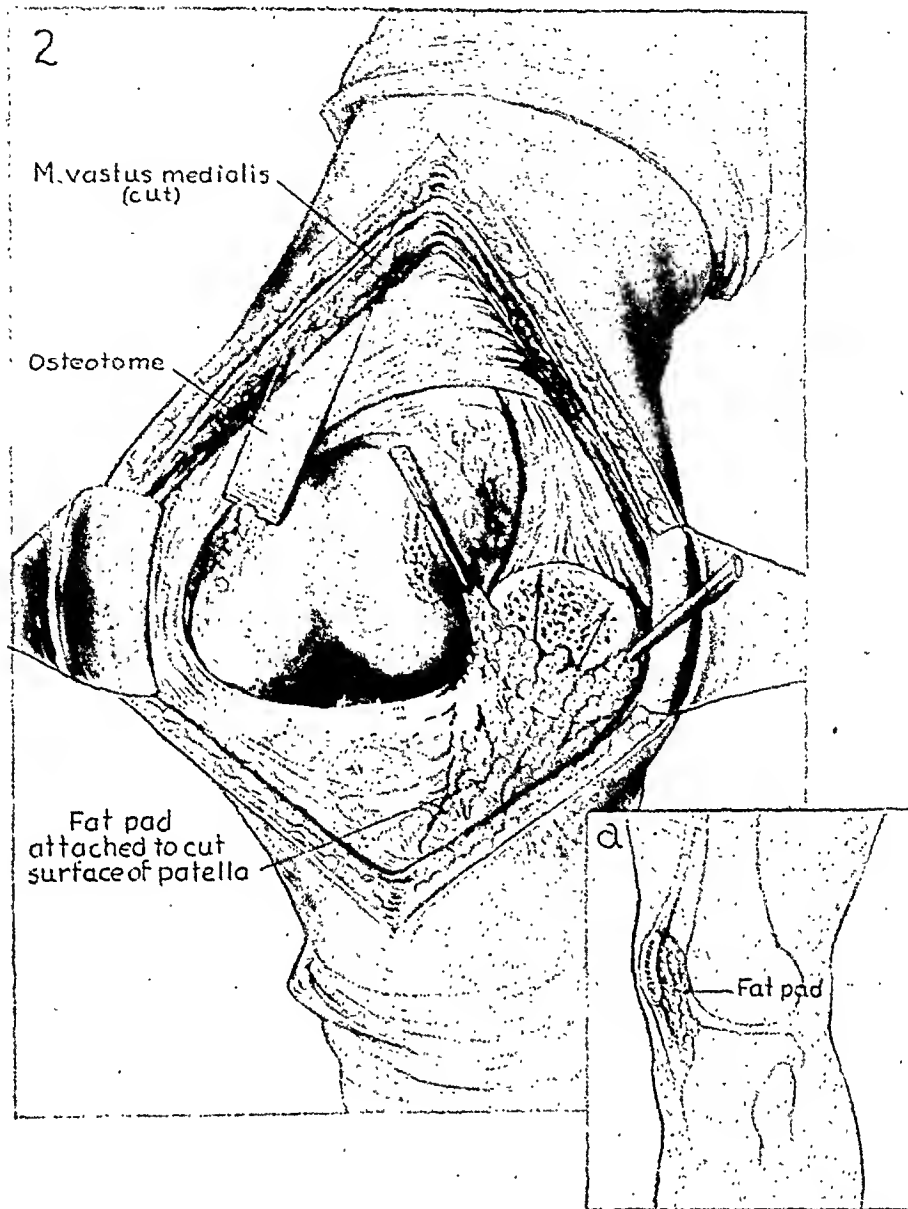


FIG. 10. Half tone drawing showing, a, the position of the sectioned infrapatellar fat pad as used to cover the posterior patellar surface. 2, the main drawing, shows removal of the marginal osteophytes on the femoral condyle by tangential trimming with an osteotome and the application of the fat graft to cover the raw posterior patellar surface.

chief results achieved in these two cases were relief from pain and soft tissue swelling around the joint.

#### THE SHOULDER

Two groups of cases of degenerative arthritis of the shoulder joint were operated upon. Cases that warrant operative procedure on the bony components of the shoulder joint aiming at motion are not frequently met, as the majority of cases of trauma to the shoulder result in injury to the soft tissue structures. The six cases reported here are divided into two groups:

A: Two cases of ancient marginal fractures

of the humeral head with extreme deformity of the humeral head, degenerative arthritis of the glenoid and lack of motion as a result of interlocking between humeral head osteophytes and the glenoid (Fig. 12.)

B: Four cases of minimal degenerative arthritis of the glenoid face with production of posterior marginal osteophytes. These were all occupational in origin occurring in glass blowers.

*Operative Technic.* The most universally applicable approach to the shoulder for exploration and operation on the glenoid is by the

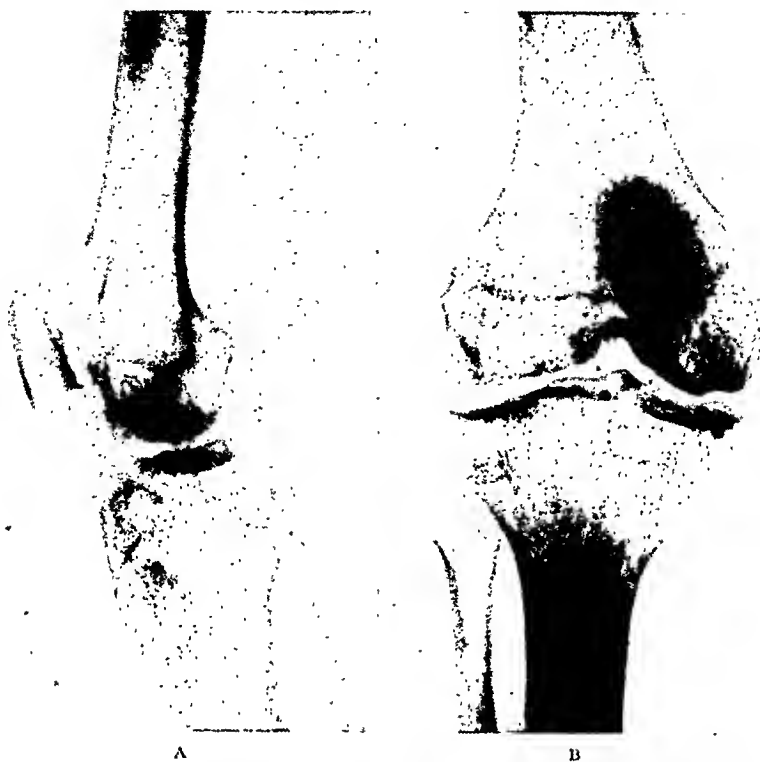


FIG. 11. A and B, preoperative views of a knee, the seat of degenerative arthritis twenty years after a pyogenic joint infection in adolescence. The operation consisted of excision of the posterior two-thirds of the patella and smoothing of the condylar surfaces, both marginal and articular. The patient was fully relieved of pain, and postoperative active motion of the joint was 50 per cent greater, due to abolition of muscle spasm. The final range of motion was 75 degrees from 175 degrees.



FIG. 11. C, lateral postoperative view of knee.

posterior route. The origin of the fibers of the posterior third of the deltoid are stripped from the scapular spine and reflected outward. The tendinous portion of the infraspinatus and teres minor is incised, and the joint capsule stripped from the posterior margin of the glenoid, when it is desired to remove osteophytes from this region. If there are no posterior glenoidal osteophytes, and it is desired to operate on the femoral head or inspect the interior of the joint, the capsule is opened by a vertical incision. In the two cases of ancient marginal fracture of the humeral head with gross deformity of this structure, the several spheres of curvature of the humeral head were reduced into a single smaller curved structure. Care is taken not to resect bone below the anatomic neck of the humerus. The attachment of the musculotendinous cuff is left intact. (Fig. 12.)

**Results.** The period of observation in the two cases in which partial resection of the humeral head was performed have been eight months in one case and four years in another. In one case, 110 degrees of active abduction of

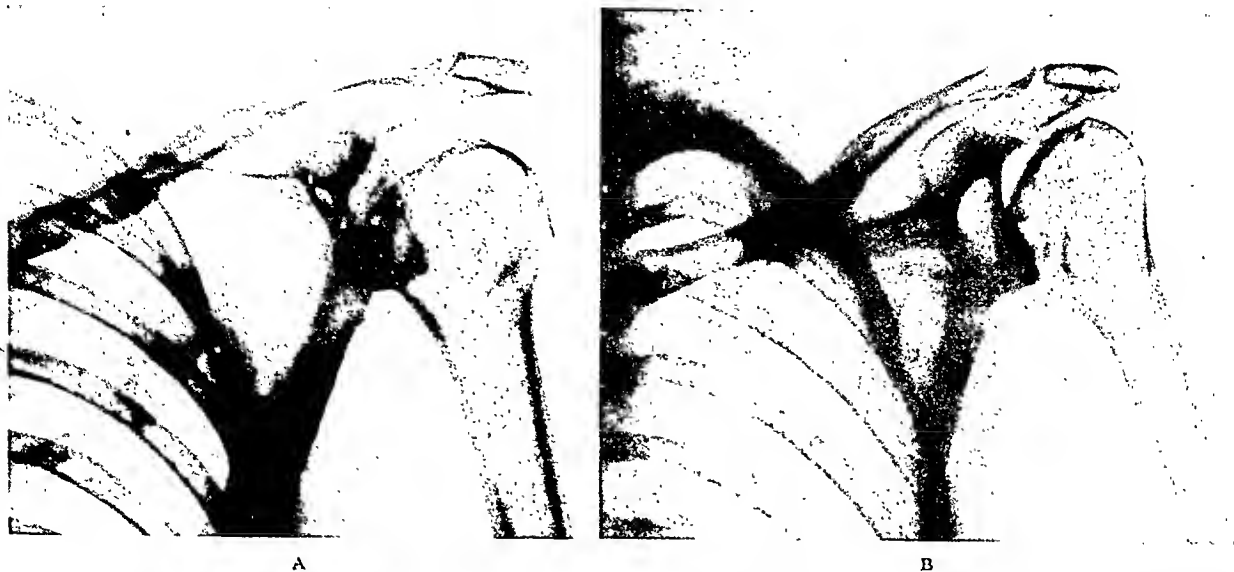


FIG. 12. A and B, the preoperative anteroposterior views of a shoulder, the seat of extensive degenerative arthritis complication marginal glenoid and marginal humeral head fractures. These views were made four years after the fracture occurred. A, an anteroposterior view in neutral; B, an anteroposterior view in extreme internal rotation. Note that there are three centers of curvature for the deformed humeral head. These osseous ridges interlocked with the posterior-inferior glenoidal osteophyte, resulting in almost complete elimination of shoulder joint motion accompanied by pain and weakness of grasp when attempting to abduct.

humerus on glenoid were secured, and in the other case, 80 degrees. Thirty-five degrees of external rotation was obtained in one case, and 90 degrees in the other. The functional results in both cases were excellent and there was no pain.

In the four cases in which resection of posterior glenoid rim osteophytes was performed in glass blowers, a normal range of motion without pain was secured in three cases and a near normal range of motion in a fourth case, but with a certain amount of continued pain. Three of these four latter cases returned to work in eight weeks. The fourth patient changed his occupation. The period of observation was one year in two cases and three years in two others.

#### SUMMARY AND CONCLUSIONS

Long term follow-up instances of operations performed for increasing motion and improving the mechanical conditions in joints are presented. The majority of these patients exhibited post-traumatic degenerative arthritis.

Arthroplasty with plastic cups on single damaged hips exhibiting degenerative arthritis or aseptic necrosis of the femoral head, evaluated five to seven years after operation, showed 61.1 per cent good results and 22.2 per cent poor results. A detailed study of roentgenograms in these cases revealed further aseptic change or wearing away of the head in



FIG. 12. C, the postoperative view demonstrating maximum passive abduction, which was approximately 90 degrees.

most of the cases rated as fair or poor. The complication of fracture of the acrylic cup was observed in two instances in these restricted etiological groups. As a result of these observations, the operative technic has been changed in the direction of major operative attack on the acetabulum with minimal operating on the femoral head consistent with removing marginal osteophytes and securing a mechanically sound hip joint with loose fit of the femoral

head within the cup and the cup within the acetabulum. An improved plastic cup,  $\frac{3}{16}$  inch in thickness and manufactured from a solid block of harder acrylic resin is now used. In the few cases in which an extremely thin interpositional material is required, Vitallium cups are used. These latter cases are those requiring little removal of bone and cartilage in securing a mechanically sound joint.

The results from arthroplasty on the hip in unilateral degenerative joints, all post-traumatic in origin, in which the slightly thicker plastic cups have been used and in which the primary operative attack is on the acetabulum, show 87 per cent good results. The evaluation was made one and one-half to three years following operation. The criterion of a "good" result is increase in motion, complete or nearly complete elimination of pain and a satisfactory result for the patient requiring no auxiliary support such as canes.

Exostectomy on the femoral head and acetabulum without using interpositional material is a palliative operation which may be indicated as a preliminary to arthroplasty or subsequent joint fusion. Eighty per cent can be expected to be improved for a variable period of time. The three-year and longer term results from this operation are not as favorable as those from the improved technic for cup arthroplasty.

Partial patellaplasty for post-traumatic chondrodystrophy of the patella has yielded excellent results with normal functioning knees in four cases. Patellaplasty combined with joint débridement gave good results in thirty-one of thirty-three cases (93.9 per cent) of unilateral degenerative arthritis of the knee joint. Half of these cases had a major traumatic history with or without fracture.

Improved function and elimination of pain occurred in two cases in which a partial resection of the humeral head was done in cases of post-traumatic arthritis following humeral head fractures in which the restriction in motion was due to interlocking of osteophytes and other osseous and cartilaginous mechanical difficulties within the joint. Full improvement occurred in three of four cases of glass blowers' shoulder, a condition characterized by posterior glenoidal osteophytes.

None of these procedures should be carried out on hips, knees or shoulders in which cartilage degeneration is nearly complete, as arthrodesis of the joint will give a more

satisfactory result for those patients who must depend on the extremity.

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#### DISCUSSION

KELLOGG SPEED (Chicago, Ill.): Perhaps you will agree with me that this is rather a difficult paper to discuss in its range of subject.

Dr. Harmon's treatment of this extensive series of limited and painful motion in various joints following trauma aims to gain increased functional

results by various means for varying causes. Surgical efforts are induced to dissipate the patient's distress and to return such functional range of motion in the given joint so that re-employment may follow.

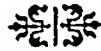
My experience coincides with some of the points he enumerates. It is remarkable how much improvement may be returned after rather simple excision of blocking or confining bone-cartilage restriction about or in a joint, followed by controlled active and passive motion and perseverance on the part of surgeon and patient.

Whether arthroplasty with an intervening foreign body is required in any case calls for experienced surgical judgment. Its best use seems to be in the weight-bearing joints. In my experience, arthroplasty for pure or long standing osteoarthritis often results in final recurrence of pain, stiffening and failure, the disease being systemic with unrecognized extension of the local process. Often in pure traumatic or mild infectious arthritis which is local, excluding tuberculosis, results are acceptable and lasting. In the hip, not enough attention is paid to free excavation of the acetabulum and less whittling down of the head of the femur, as he has brought out, but I believe that it is more important to preserve the integrity of the "Y" ligament of the hip rather than to attempt to save the fibrous capsule of the joint which has rapidly regenerating powers.

Of all the joints, the elbow gives the least satisfactory result on anatomical grounds alone. The small joints of the finger respond well to delicate treatment. Selection of material for surgically formed new joint coverage or protection is a matter of choice by the surgeon. More depends on the delicate yet extensive restoration of freedom of joint motion and removal of all blocking mechanical hindrance than on the material used to cover raw bony surfaces. Fascia lata with a fat layer is always available. The postoperative muscle training and restoration of the patient's morale become major points in the follow-up.

These procedures involve complicated and custom made surgery to fit each case. They lead to lessened disability and decreased economic loss. If failures arise purely on the basis of changed or decreased blood supply, an attempt to increase this supply locally by using transplanted pedicled muscle flaps into the bone, as suggested by Stuck and Hinehey, may, after further trial, be found to be of definite and lasting value. This is doubtful, however, as the implanted muscle, losing its normal function, atrophies rapidly, thus losing vascularity.

I would like to say, in the case of the knee, I have done a few of these by shaving off the patella and putting fat over them and going back in nearly every instance within a year and finally removing the patella, much to the patient's advantage.





# PERIOSTEUM FOR REPAIR OF FASCIAL DEFECTS IN THE PARATIBIAL REGION OF THE LEG

## RESULT OF ITS TRANSPOSITION

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LERICHE and Policard in their excellent book on bone physiology and pathology state: "The periosteum is the fibrous membrane which surrounds bones and separates them from the environing tissue: it is nothing more."<sup>1</sup>

With this statement in mind the following proeedure was developed for repair of faseial defects which ooeur along the lateral margin of the shaft of the tibia. An investigation of the literature does not reveal any previous report of the use of this method. The author wishes to present two cases repaired by the use of this procedurc and by the end result achieved further strengthen the stand taken by Leriche, Policard, MacEwen, Goodsir, Murray and others that the periosteum in the adult is only a limiting membrane and has no osteogenic function *per se*.

CASE I. (Mr. H. C. K.) The patient was seen on January 26, 1946, complaining of pain and swelling on the anterior aspect of the right leg just lateral to the edge of the tibia in the mid-portion. He stated that this mass had been present for the past two or three months and had been getting progressively larger. The patient suffered a compound fracture of the lower third of his right tibia while in combat and had been hospitalized for a period of approximately six months. He first noticed the presence of a very small painless mass in the lateral paratibial region at the level of the fracture site when the cast was removed, and this mass was still present when the patient was discharged from the service. However, because of no discomfort over this mass and over the surrounding area, the patient did not complain about it. Since his return to work as a truck driver, he had pain not only over the fracture site, but over the previously described mass, particularly after a day's work or any excessive walking. He had noticed that with changes in weather he experienced aggravation of the pain at the fracture site. The mass was not located at the fracture site but little higher up on the leg. The patient had observed that it was increasing in size and in symptomatology.

Examination revealed a well developed, well

nourished, twenty-three year old white male, who walked into the oflice with a slight limp of his right lower extremity.

Examination of the right leg revealed the presence of a mass on the anterolateral aspect of the leg at the mid-portion just lateral to the edge of the tibia. This mass was 1 inch in width, at its widest portion, and approximately 3 inches in length. There was definite tenderness present upon pressure, and the underlying muscle belly could be easily palpated and delineated when the patient stood up. The edge of the fascia could also be palpated. At rest the mass reduced somewhat in size, but the tenderness was still present. A diagnosis of muscle hernia on the anterior aspect of the right leg at the junction of the upper and lower halves of the shaft of the tibia was made.

The patient was advised that surgery was the only therapy which could be prescribed in this instance. He was told that an attempt would be made to repair the hernia if this was at all possible. However, if this were impossible, the fascia would be split along the entire length of the leg thus releasing the tension along the fascial edge.

On February 13, 1946, repair of the hernia was performed under general anesthesia with the use of a tourniquet. The operative procedure was as follows:

A 7-inch curved incision was made on the lateral aspect of the leg beginning just below the level of the tibial tubercle and extending distally. A definite defect of the fascia was found at the level of the mid-shaft of the tibia. This defect permitted protrusion of the underlying musculature through the opening. In addition to this, however, there was marked thinning of the fascia proximally and distally for a distance of 4½ inches. The fascia was detached from the tibia and the defect was at least 1¼ inches wide. An attempt was made to reattach the fascia to the periosteum, but this was impossible. Accordingly, therefore, an incision was made on the periosteum at its medial edge for a distance of at least 6 inches. A flap of the periosteum was then developed following which this structure was lifted, by the use of a blunt periosteal elevator, from the anteromedial surface of the tibia and attached to the fascia along its entire length. The defect was thus closed over

with interrupted No. 60 white cotton sutures. At the end of the closure there was separation of the muscle mass from the lateral tibial surface since the periosteum was pulled over to the fascial edge, but the defect was entirely closed. The skin was closed with interrupted No. 60 white cotton sutures, and a long leg cast was applied extending from the toes to the mid-thigh with the ankle at 90 degrees dorsiflexion and the knee at 15 degrees flexion.

The cast was removed at the end of a six weeks' period. During this time the patient was not permitted to bear any weight on the involved extremity. Following removal of the cast, active weight bearing was permitted, and the patient was allowed to return to work as a truck driver at the end of ten weeks.

The patient has been seen on several occasions since then, the last occasion being on April 12, 1947, at which time a biopsy of the leg was performed under local anesthesia. A  $1\frac{1}{2}$  inch incision was made just along the lateral tibial edge in the region of the mid-shaft of the tibia, and a specimen of tissue was removed from the area of the fascial defect, as well as another specimen from the surface of the tibia. The area of the herniation appeared to be well healed and there was no evidence at this time of any thinning of the overlying tissues. In regard to the tibia itself a new layer of fibrous tissue, or rather a new layer of tissue, covered the antero-medial surface of the tibial shaft, and this tissue was well adherent to the bone. Microscopic sections of both specimens were made.

**CASE II.** Mr. H. B. was a twenty-four year old, white male, who stated that approximately three years ago, while in the service, he was involved in a plane crash at which time he suffered a simple fracture of his left tibia. Accordingly, he was hospitalized at that time and his leg was immobilized in a cast. Active weight-bearing was begun at the end of three months when the cast was removed. He began to have pain over the fracture region and just a little lateral to it, and he was finally discharged from the service because of his disability.

Because of continued symptomatology he reported to the Veterans Hospital in Dayton, Ohio, in October, 1944. At this installation a diagnosis of muscle hernia of the mid-paratibial region of the left leg was made, and this was repaired by using fascia from the opposite thigh. For approximately a year following this the patient had no symptomatology whatever. On October 14, 1945, he was involved in another plane crash, and in preparing and bracing himself for the crash when he landed, the patient felt a sudden searing pain in his leg and noticed the reappearance of the hernia within twenty-four hours.

Since that time the patient had been having a



FIG. 1. There is no evidence of any bone formation where the periosteum covers the muscle hernia.

great deal of disability with the left lower extremity and he was finally seen at the office complaining of aching along the anterior mid-portion of the leg whenever he walked for any length of time or performed any strenuous work. Damp weather seemed to aggravate the situation a great deal. He further stated that he noticed his toes tended to drag a little whenever the leg was tired. When first arising in the morning, the leg was somewhat stiff and painful, but not as severe as it was after a day's work.

Examination revealed a well developed, well nourished, white male, who walked into the office in no apparent discomfort.

Examination of the left lower extremity was essentially negative, except for the left leg. A 4-inch scar was present on the anterolateral aspect of the leg just lateral to the tibial edge at the mid-portion. The scar and the surrounding tissue, particularly at the edge of the tibia, were quite tender to touch. Upon standing there was a definite herniation present of the muscle bellies of the extensor digitorum longus. The mass which was palpable was 5 inches in length and approximately  $1\frac{1}{2}$  inches in width.

A diagnosis of muscle hernia of the leg due to rupture of the fascia overlying the musculature in the middle paratibial region of the left leg was made.

The patient was advised that the recommended form of therapy here would be another repair of the herniation. Accordingly, on June 24, 1946, the patient was hospitalized and on the following day operative repair of the muscle hernia was carried out.

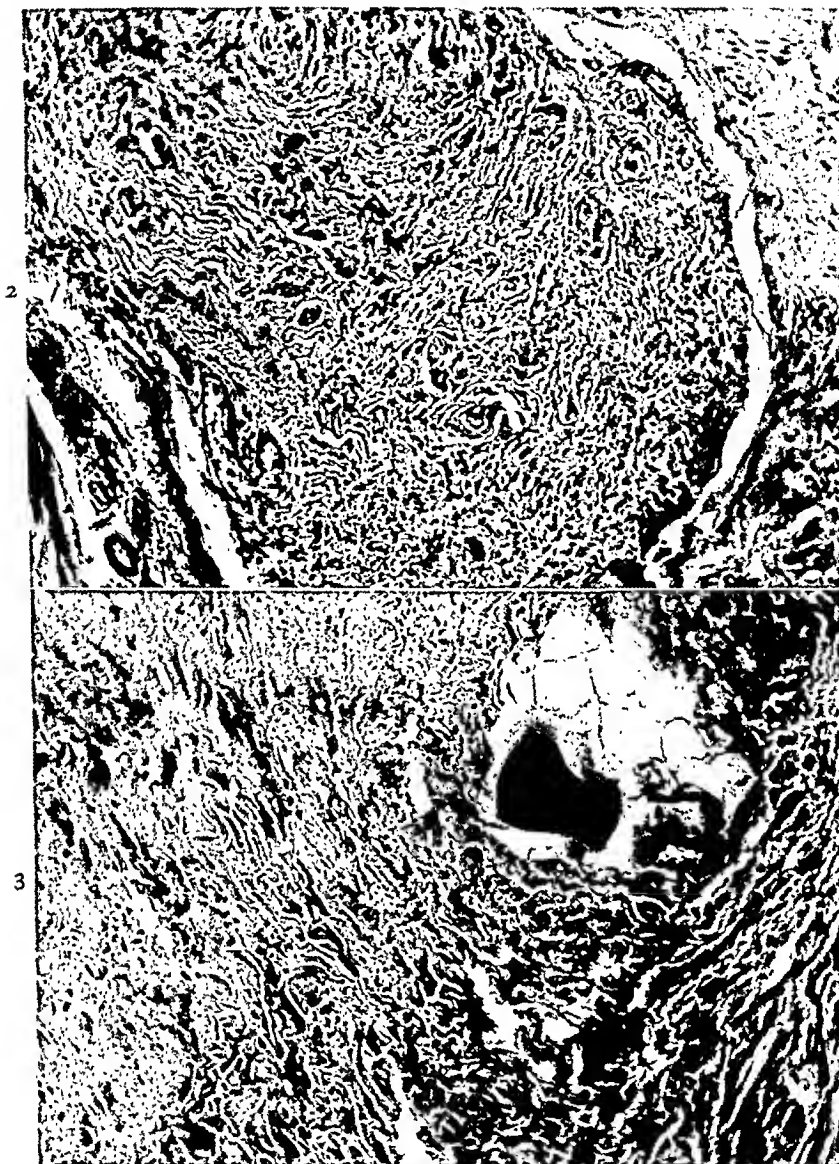


FIG. 2. Section of transplant. Microscopic section reveals the tissue to consist chiefly of collagen as verified by the trichrome stain. Several areas of fibroblastic proliferation are seen accompanied by some multinucleated cells suggestive of foreign body reaction.

FIG. 3. Section of new tissue covering bone. Tissue composed of fat on one surface while the other border reveals collagenous material with flecks of calcium. The collagen is relatively acellular.

At operation it was found that the fascia was torn from its tibial edge on the lateral aspect of the tibia for a distance of approximately 7 inches extending from the junction of the upper and middle thirds of the tibia distally. The width of the hernia was between 3 to 4 inches at its widest portion. A 12-inch incision was made along the lateral edge of the tibia. The old scar was excised, following which the skin was reflected laterally exposing the entire muscle hernia. The edge of the fascia was identified and was freed on the lateral aspect of the leg. Following this the periosteum of

the tibia was incised along its medial edge from the level of the tibial tubercle and extended distally to 3 inches above the ankle joint. Transverse incisions were made at each end thus permitting lifting of the periosteum of the tibia with a blunt periosteal elevator. Following this the periosteum was stripped from the lateral surface of the tibia as well to permit approximation of the periosteum to the fascial edge. Upon approximation these two structures were sutured together in an overlapping fashion with interrupted No. 60 white cotton mattress sutures. The skin was also closed with

interrupted No. 60 white cotton sutures. A long leg cast was applied from the mid-thigh to the toes with the knee at complete extension and the foot at 90 degrees dorsiflexion. The cast was kept on for a period of six weeks, and upon removal of the same active weight-bearing was permitted.

The patient has been seen on repeated occasions since this time, and has come along quite satisfactorily. On February 17, 1947, the patient came into the office complaining of some pain over the region of the herniation and stated that the day before he had slipped and fallen and was afraid that he might have injured the operated area. Examination did not reveal any recurrence of the hernia.

The patient was last seen on March 29, 1947, at which time biopsy of the operative site was carried out under local anesthesia, and specimens were removed both from the transposed periosteum and the tissue which was present on the anterior tibial surface.

In Case 1 it is now fourteen months since the operation was performed. The patient states that his condition is vastly improved. He is able to work every day at his occupation as truck driver, and except for some pain at the end of a day's work over the operative site and a feeling of fullness in his leg, he has no complaints whatever.

Roentgenograms taken recently (Fig. 1) reveal no evidence of bone formation where the periosteum covers the muscle hernia. Microscopic sections of this structure (Fig. 2) taken on April 12, 1947, revealed that the tissue consisted chiefly of collagen as verified by trichrome stain. Several areas of fibroblastic proliferation were present, accompanied by some multinucleated cells suggestive of foreign-body reaction. No tubercles were noted, though the area appeared granulomatous. Microscopic sections of the new layer of tissue covering the tibia from the area from which the periosteum was removed previously (Fig. 3) revealed that this tissue was composed of fat on one surface, while the other border was collagenous with flecks of calcium. The collagen was relatively acellular.

In Case 11 it is now ten months since operation. This patient is at the present writing waiting until June 1st of this year before reporting to St. Louis Browns as a pitcher. He has absolutely no symptomatology in reference to his leg. He is able to carry on with no difficulty whatever. His x-rays (Fig. 4) also reveal no aberrant bone tissue, and the microscopic examination (Fig. 5) of the periosteal graft covering the fascial defect revealed that the tissue consisted chiefly of dense collagen which bore numerous small blood vessels. Diagnosis of dense collagenous tissue bearing numerous new blood vessels was made. Microscopic examination of the tissue covering the tibia (Fig. 6) revealed that approximately one-half of the section consisted of



Fig. 4. No aberrant bone tissue is visible by x-ray in the area of the transplant of the periosteum over the hernia in the soft tissues.

adipose tissue, while the other half was made up chiefly of dense collagenous tissue. Much of the latter tissue was infiltrated with numerous red blood cells and a scattering of lymphocytes and polymorphonuclear cells. The entire tissue was fairly vascular. No evidence of new bone or calcification was seen. Diagnosis of vascular collagenous tissue bearing hemorrhage was made.

Thus we have two cases in which the periosteum, detached on three sides and permitting maintenance of circulation along the entire length of the graft from its attached side, did not produce any bone.

The main result from this operation is the fact that in each patient the defect was corrected without the necessity of "robbing Peter to pay Paul" by taking a fascial graft from the thigh. Of course, as one of my conferees suggested, Why not split the fascia along the entire length of the tibia and thus relax the fascial edge? In the first patient this procedure might have been successful since the fascial defect involved only approximately three-fifths of the length of the shaft of the tibia, but in the second patient the defect already extended from approximately just below the level of the tibial tubercle to 3 inches above the ankle joint, and the leg was still symptomatic.

The second conclusion to be derived from this procedure is that there are presented here two proved human cases in which periosteum, not



FIG. 5. Section of transplant. Tissue consists chiefly of dense collagenous fibers and collagen with numerous small blood vessels.

FIG. 6. Section of new tissue covering bone. Approximately one-half of this section consists of adipose tissue. The other half is made up chiefly of dense collagenous tissue which is infiltrated with numerous blood cells and a scattering of lymphocytes and polymorphonuclear cells. The entire tissue is fairly vascular. There is no evidence of any bone formation or calcification.

completely detached and, therefore, having a relatively good circulation, did not go on to bone production. Sir William MacEwen<sup>2</sup> basing his conclusions on thirty-two animal experiments and his long surgical experience held that periosteum, whether *in situ* or in transplant, has no osteogenic function. The bone growth results solely from bone cell activity. The periosteum acts only as a limiting membrane to the osteoblasts issuing from the interior of the bone. Blaisdel and Cowan<sup>3</sup> reported as follows: "The periosteum of the bones

of young growing animals is quite thick, vascular, elastic and abundantly supplied with osteoblasts on its inner layer. If we compare this with the periosteum of an adult animal, one that has attained its growth, we find that this periosteum is relatively less thick, less vascular and elastic and that the osteoblasts are either flattened against the cortical surface as a single layer, visible at intervals, or very difficult to recognize or even absent." Murray,<sup>4</sup> in his numerous articles on the physiology of bone and bone healing, contends that the periosteum

is a limiting membrane and has no reparative function.

How then can these above statements be reconciled with Mayer's and Wehner's experiments<sup>5</sup> who, in carrying out their study of bone osteogenesis, came to the conclusion that the "transplants of the periosteum, subperiosteal resections, and bone transplants combine to emphasize the osteogenetic function of the specific osteoblastic cells of the periosteum and the inability of the adult bone cells to form new osseous growth."

This contention is also borne out by the excellent work of Urist and Johnson<sup>6</sup> who state that the intermembranous bone formation arises between the periosteum and the shaft by the proliferation of spindle-shaped cells in the inner periosteum which resemble fibroblasts which are termed "resting osteoblasts."

The author cannot and will not be so presumptuous, on the basis of two cases and the reading of many articles, to attempt to credit or discredit either school of thought, for the exponents of each school have performed a great deal of experimental work on a very controversial subject. The only conclusions which can be derived from these two cases are that: (1) An operative procedure is presented in which periosteum in the adult human can be used to bridge fascial defects in the paratibial region of the leg with good results; (2) that in *neither* instance was any bone developed by the transposed periosteum as evidenced by the roentgenograms and the biopsy studies, in spite of the voluminous literature to the effect that periosteum begets bone; and (3) that a new layer of fibrous tissue, definitely as adherent to the tibia as the periosteum had been previously, and resembling the previous periosteal layer was found to cover the outer cortex of the tibia.

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#### DISCUSSION

LAURIE H. MCKIM (Montreal, Canada): I wish to thank Dr. Giannestras for the privilege of opening the discussion on this very interesting paper. I believe there will be other speakers who will review some of the controversial points which he has brought up.

I wish to take up only two aspects of this subject. I have noted that the cases that are reported by Dr. Giannestras are both the result of fractures of the leg. The cases that the majority of us saw in the Army were not the result of trauma, but were due to a congenital opening in the fascia. They were small in size, although some of them were as much as 2 inches in a vertical direction. Frequently, they were the site of a communicating vein between the superficial and the deep venous systems.

The majority of such patients were completely relieved of their complaints of pain or disability by the simple ligation of this communicating vein or sometimes even by the injection of some sclerosing material in the vein. Certain others were relieved by the procedure that Dr. Giannestras has spoken of, splitting of the fascia in a vertical direction, sometimes slightly in the lateral direction.

I would just like to call to mind the experience of many of us when we used to use fascia lata from the thigh for the repair of hernia, when we used to make a huge opening in the thigh and very carefully tried to close the fascia. The sutures did not hold and, of course, we got small muscle hernias through the openings in this long incision in the fascia and the patient complained of pain. In the course of time, the majority of us learned that it did not matter whether or not you closed these openings in the fascia; and with the introduction of the fascia stripper, you could not close them. Since the introduction of the fascia stripper, we have had very few complaints of pain.

Now, all of this is just to bring up the question as to what disability if any, the members of this Society believe these small hernias produce. How much disability have those men actually got?

The second point that I wish to discuss is the function, if any, of the periosteum as a bone-forming membrane. Dr. Giannestras has referred to the work of Leriche and Policard, which was published about 1926, as I remember it. About 1931, Gregg, of Edinburgh, published a very interesting book on the pathology of bone, and in that book he made this statement: "The osteogenetic ability of the periosteum remains unproved, and its non-partici-



pation as a bone-forming membrane is now widely accepted."

The work of Dr. Giannestras would seem to have added one more nail in the coffin of the ancient theory that the periosteum had very much to do as a bone-forming membrane.

I just wonder whether any member of this Society really thinks that there is any such thing as a true osteoblast. Does any member actually think that there is such a thing as a cell that is capable of producing bone under any conditions of growth, whether in transplant or otherwise? You will observe that I have used the words "true osteoblast."

FREDERIC W. BANCROFT (New York, N.Y.): About 1915, antedating Dr. Murray's work, I did a good deal of work on experimental bone formation and functions of the osteoblasts and of the periosteum. The main experiment, which I think showed a good many of the factors involved, was taking a piece out of the radius in dogs, chopping it into small fragments and removing the periosteum and replacing the bone fragments. The more one studied the microscopical repair of bone, the more one came to the realization that there was no such thing as an osteoblast.

In the repair, blood vessels come in and there is granulation tissue with fibroblasts. Now, around these fibroblasts, one begins to see bone reaction; but if one goes to the borderline of this bone reaction, one finds a gradual transition between the so-called osteoblast and the fibroblast, and I defy anybody to say which is fibroblast and which is osteoblast. As they come into the deposition of calcium around the granulation tissue a perfectly regular repair is formed, blood vessels come in, an area of areolar tissue around the blood vessels occur, and calcium deposition and fibroblasts in this surrounding tissue appear.

One finds definite cartilage cells where there is motion. As one goes to transition between cartilage and fibroblast, one can say, "Here is a cartilage cell and there is a fibroblast," but then there is a transition area where one cannot differentiate. You can observe an intermediary zone and you and I might argue that one is a cartilage and the other, a fibroblast. Therefore, it is my impression that bone formation is the result of deposition of calcium salts on granulation tissue, where the cell is caught in and is not the cause of the process.

I think that is true with periosteum. We tried numerous places where one could transplant periosteum. If you transplant periosteum where there is a base rich in calcium, as in the bladder, you are apt to see bone formation. One can produce bone formation in the kidney by ligating its vessels and wrapping the omentum around it. Here one will find bone cells in the kidney itself. It is very hard to tell why. In the bladder, one may insert a fascia lata transplant and get true bone formation.

Why do osteoblasts wander into the fascia lata that one uses for transplants in the bladder? Why do osteoblasts wander into a kidney that has been deprived of its circulation and new circulation re-established?

The observer has to come to the conclusion that bone formation is a biochemical deposit of calcium on granulation tissue, and that the so-called fibroblast by metaplasia becomes an osteoblast.

MARSHALL R. URIST (Boston, Mass.): Dr. Giannestras, prior to the time of the reading of his paper, had informally challenged me to defend my thesis on the mechanism of osteogenesis in healing fractures reported in four papers in the *Journal of Bone and Joint Surgery* between 1941 and 1943. The point of disagreement between us, as I gather from his conclusions this morning, is the question of the function of the periosteum, a controversy in the literature nearly three hundred years old. Briefly our view was that new bone comes from pre-existing bone tissue in response to the stimulus of injury. This applied to the replacement of bone grafts as well as the healing of fractures. In healing fractures which is the condition to which I should limit my remarks, the new bone forms by differentiation of osteoblasts beginning between the cortex and the periosteum some distance from the fracture line. There is little doubt as to the identity of these cells or that they originate in the cambium layer of the periosteum. The reaction of the periosteum and this type of new bone formation also occurs not only with bone injury after trauma but also with infection or neoplasm.

This is not the time for a discourse on the histophysiology of the bone cell, even if I could answer, which I cannot, all the important questions which I have heard this morning. Rather I would refer you to the recent work of McLean and Bloom and the tissue culture studies of Heinen, whose writings have been communicated thus far mainly to non-clinical audiences, but to which I subscribe and believe will one day be extended closer to our clinical problems. In healing fractures, just as in other conditions, we find that whenever bone trabeculae form, a specific cell is also present which can be identified histologically as an osteoblast. Injured bone apparently has the effect of inducing the proliferation of osteoblasts connective tissue cells surrounding viable bone. In healing fractures the process is set off like a trigger mechanism and rapidly goes to the point of repair of the bone defect.

It is established from a great number of well known experimental works, that a graft of periosteum isolated from bone tissue gives little or no new bone formation. Our interpretation of this fact and the experiments of Dr. Giannestras, is that the periosteum does not demonstrate osteogenic potency without the stimulus of injured bone.



I would assume that the cambium layer, which has a blood supply of terminal penetrating capillaries, dies when it is stripped up or transplanted into soft parts. Presumably after this happened in Dr. Giannestras operation, and without the osteogenic stimulus from injured bone, the surviving periosteum failed to proliferate and produce osteoblasts or new bone.

The lack of osteogenic potency in the transplanted periosteum may be interpreted by Dr. Giannestras as evidence against the "osteoblastic theory" and as corroborative data for the "metaplasia theory" of Leriche and Policard, the writings of Murray and Stirling, the experiments presented yesterday by Hudack and the remarks this morning of Dr. Bancroft. We believe that our experiments show that new bone formation in healing fractures comes with the formation of osteoblasts which develop from the periosteum and the endosteum, rather than by metaplasia of connective tissue cells directly into bone by such factors as small variations in pH or local calcium ion concentration. To reconcile ourselves with the conclusions of Hudack, we would question the identity of matrix without bone cells. We wonder if the material which he finds between the filaments of lucite is old fibrin. Nearly everyone would agree with Dr. Bancroft that osteoblasts do not wander into the bladder. However, as clearly demonstrated by Huggins ectopic bone develops from osteoblasts *formed in connective tissues in contact* with transplanted urinary bladder epithelium. We know only very little about the osteogenic stimulus in urinary bladder epithelium, for that matter any of the conditions which produce extraskeletal bone formation, but new information appears to be coming into the scientific literature every day.

BOARDMAN M. BOSWORTH (Bronxville, N.Y.): I simply want to digress a minute and ask Dr. Giannestras if, when he did his biopsies, he found any evidence of what happens to his No. 60 cotton.

PAUL H. HARMON (Huntington, W. Va.): That there are cells whose sole function is the elaboration of the type of intercellular matrix which we know as bone, is shown by the fact that there are malignant tumors, whose metastasizing cells have the power to form a more or less typical intercellular matrix of bone. This line of evidence, of course, gives no clues concerning the normal morphogenesis of bone, but indicates that there is a type of cell sufficiently differentiated to form the typical malignant tumor, on occasion.

The common occurrence of bone in the urinary tract, especially in the bladder wall, is explained, in part, by the rich content of urinary tract epithelium in phosphatase. The property of urinary bladder epithelium to form bone when traumatized in the presence of foreign bodies, has been the

contraindicating factor to the use of non-absorbable suture material for the repair of bladder wounds. When cotton or silk is so used, calcification and often ossification occurs about the sutures.

HARRY E. MOCK (Chicago, Ill.): I had the temerity in May, 1928 to publish a paper on pure periosteal transplants in ununited fractures. I cannot resist speaking here as a clinician. In my studies and experience, pure periosteal transplants placed about the site of an ununited fracture even with loss of bone substance between the fractured ends did result in union.

During those experiments on dogs, when we would transplant periosteum in the soft tissue where there was no function called for and where it did not belong, we never got bone. But when we put it about the bone and attached it to the bone, it did beget bone or, rather, it did stimulate the growth of bone and resulted in union.

Following the Frenchman's work—I cannot think of his name—and others, we have since attached small particles of cortex to the periosteum, thus giving a containing membrane with some bone material and this stimulated the growth of bone quicker. I do not think the fact that the essayist proved that his transplanted periosteum failed to beget bone out where bone was not intended to be proves that periosteum has no value in ununited fractures.

NICHOLAS J. GIANNESTRAS (closing): Gentlemen, my head is bloody but unbowed.

I would like to thank Dr. McKim for his discussion. I agree with him that in small muscle hernias, this type of surgery is definitely not indicated.

I asked Dr. Urist, rather than challenged him, to discuss the paper because I thought he certainly had something to contribute, and I am glad that he did come up to discuss this thing, because I admit that I do not know as much about bone physiology as he does, since he has done so much experimental work. But it was simply the fact that here was something to bring out a discussion, so that we could possibly get various ideas about the matter.

He brought out the fact that the cambium layer died in the periosteum and therefore did not beget bone. The one statement that I still cannot understand is how he comes to the conclusion and how Dr. Urist can differentiate a resting osteoblast from a fibroblast. Probably that may be splitting hairs but I have tried in my own way to find out how to differentiate between a fibroblast and an osteoblast in the normal periosteum when sections have been made of it, and I agree with Dr. Bancroft that it is a rather difficult thing to do.

As far as the cotton sutures go, Dr. Bosworth, they were still in there. They had not been absorbed.

# PRACTICAL PROCEDURES FOR THE CORRECTION OF SCAR CONTRACTURES OF THE HAND\*

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**S**CAR contractures of the hands and fingers commonly arise from spontaneous healing of deep second or third degree burns, from avulsions of skin, certain lacerated wounds, or poorly planned surgical incisions. The correction of the majority of lesions of this type is not ordinarily difficult, provided certain fundamental principles are kept in mind when planning the type of repair.

The hand is a highly kinetic organ and when deciding upon the procedure to use in correcting a scar contracture, a type of operation must be utilized that will not interfere with the normal hand and finger mechanism. It must be remembered that all scars tend to contract and that any incision or suture line that runs parallel to a flexor or extensor surface will in all likelihood result ultimately in a hypertrophic scar that will produce a contracture. Hence, all incisions, suture lines and skin graft edges must be calculated so that they will fall either transversely or obliquely across the longitudinal axis of the flexor or extensor surfaces of the hands and fingers. If this design is carried out and a postoperative shortening of the suture line should occur, the pull will lose its force in a lateral direction and therefore will not interfere with the normal flexion and extension mechanisms.

## OPERATIVE PROCEDURES

Whenever possible, one should always utilize local tissues when reconstructing hand contractures if the skin loss has not been too great. Not only is the operation simpler but normal hand skin gives the best functional result. Skin grafts are a substitute to be used only when adequate tissue is not available for local use. Normal hand skin withstands daily trauma better and sensation is more nearly normal. Stereognosis can never be replaced by skin grafts from other areas since the special organs for this sensation are found only in the pacinian corpuscles located normally in the finger pulps.

Consequently, when correcting linear contractures wherein there is sufficient available skin along the borders, a single or multiple Z-plasty will give the best result with minimum surgery. (Figs. 1, 2A and B.) The use of this procedure, however, is limited to the amount of available skin flap on either side of the wound after excision of the contracting scar. Larger defects, by necessity, must be covered with a carefully selected type of skin graft.

When the necessity for the use of a skin graft arises, some type of free graft, either full-thickness or split-thickness as indicated, must always be utilized when there is an adequate subcutaneous fat pad present that covers the underlying tendons, bones and joints. If this fat pad has been lost in the original injury or its subsequent complications, one must be prepared to cover the defect with a flap of skin to which a fat pad is attached.

It is the experience of plastic surgeons doing considerable amount of hand surgery, that the best functional results occur after replacement of the skin on flexor surfaces when free full-thickness or Wolfe grafts are employed. This type of graft will give the maximum degree of elasticity and the best surface bearing qualities. (Figs. 1, 3A, 3B, 4A, 4B, 5A, 5B.)

On the other hand, one may use thick split-thickness skin grafts on the extensor surfaces to great practical advantage. These grafts are simpler to cut and may grow and they will supply sufficient elasticity and surface bearing qualities to cover defects on the backs of the hands and fingers. While one could also use the free full-thickness graft in this location, the comparative simplicity associated with the split-thickness skin graft for extensor surface defects has made it almost a standardized procedure. (Figs. 6A and B.)

Again it should be pointed out that in using either of these types of free skin grafts, one must always avoid a straight suture line along the graft edge when this line runs parallel to

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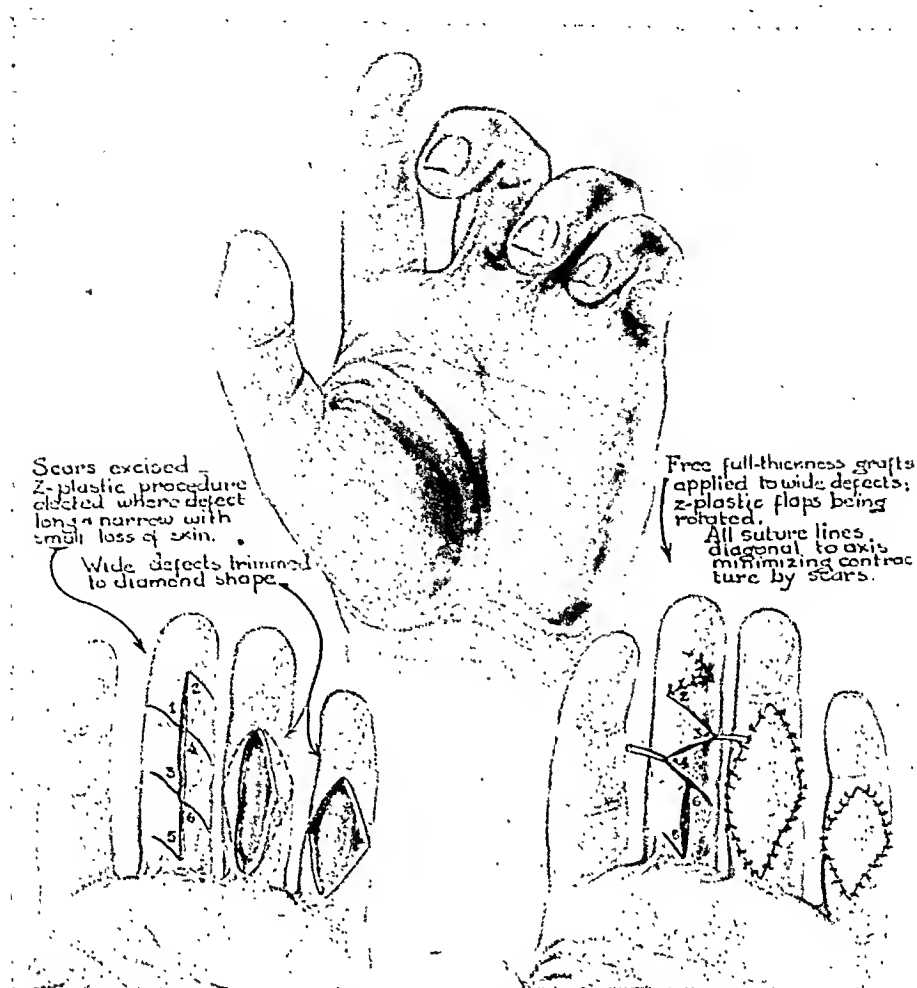


FIG. 1. Showing points of importance in correction of flexion scar contractures of the fingers. Note creation of staggered suture lines. Z-plastics preferable when adequate border skin is available.

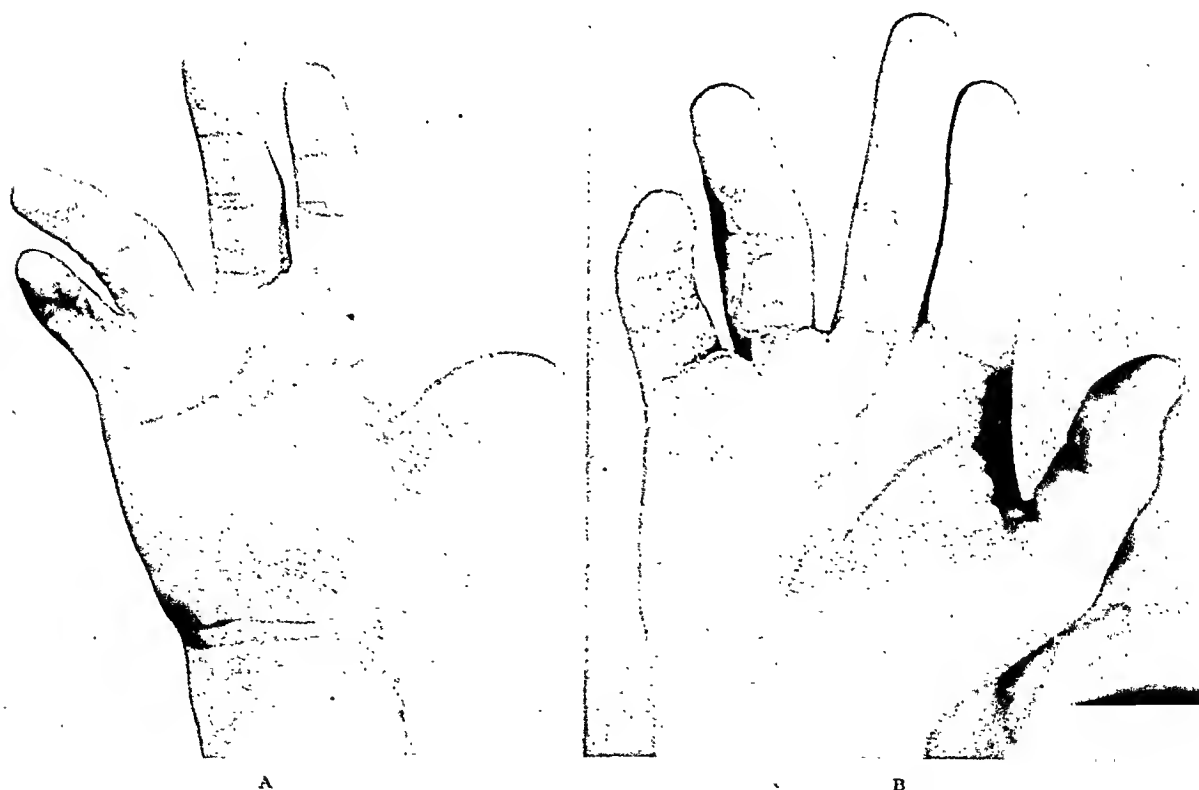
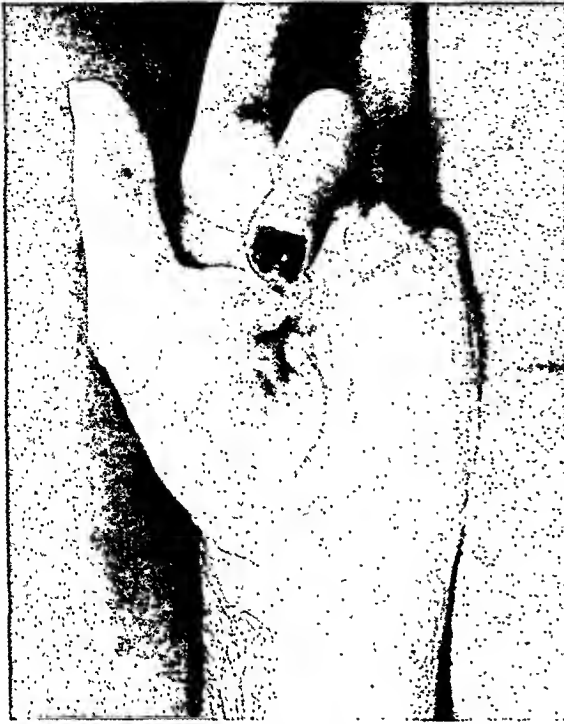
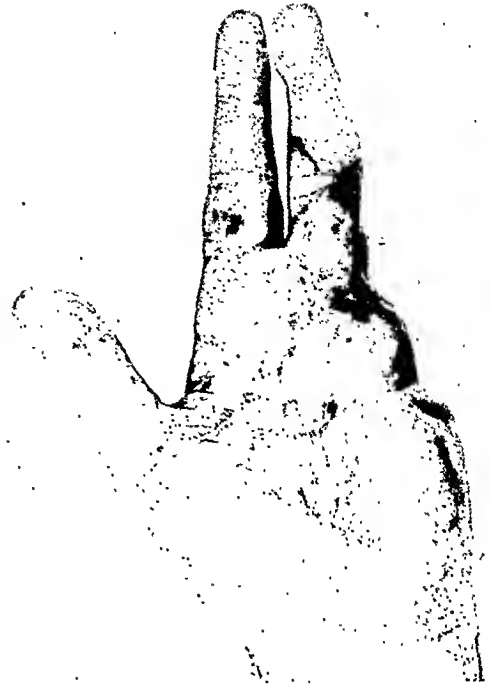


FIG. 2. A, flexion scar contractures at site of suture lines in poorly planned syndactylism operation. B, linear scar replaced by zigzag line following triple Z-plasty of fourth and fifth fingers.



A

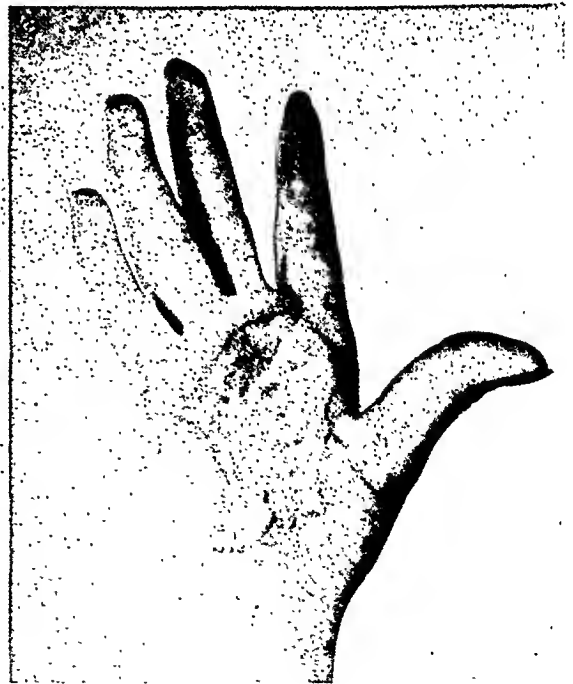


B

FIG. 3. A, inefficient hand following traumatic loss of fourth and fifth fingers plus complicating severe flexion contracture of mid-finger. B, mid-finger straightened after removal of contracting scar. Resulting defect on finger covered by Z-plasty and that of palm and base of finger by free full-thickness skin graft. (Reproduced through courtesy of U. S. Naval Hospital, Oakland, California.)



A



B

FIG. 4. A, inferior result following correction of scar contracture of palm where split skin graft had been utilized. Linear scar along ulnar border adds a further complication. B, replacement of thin graft by free full-thickness skin graft which will give greater elasticity and wear resistant qualities on palm. Also note staggering of edges along graft.

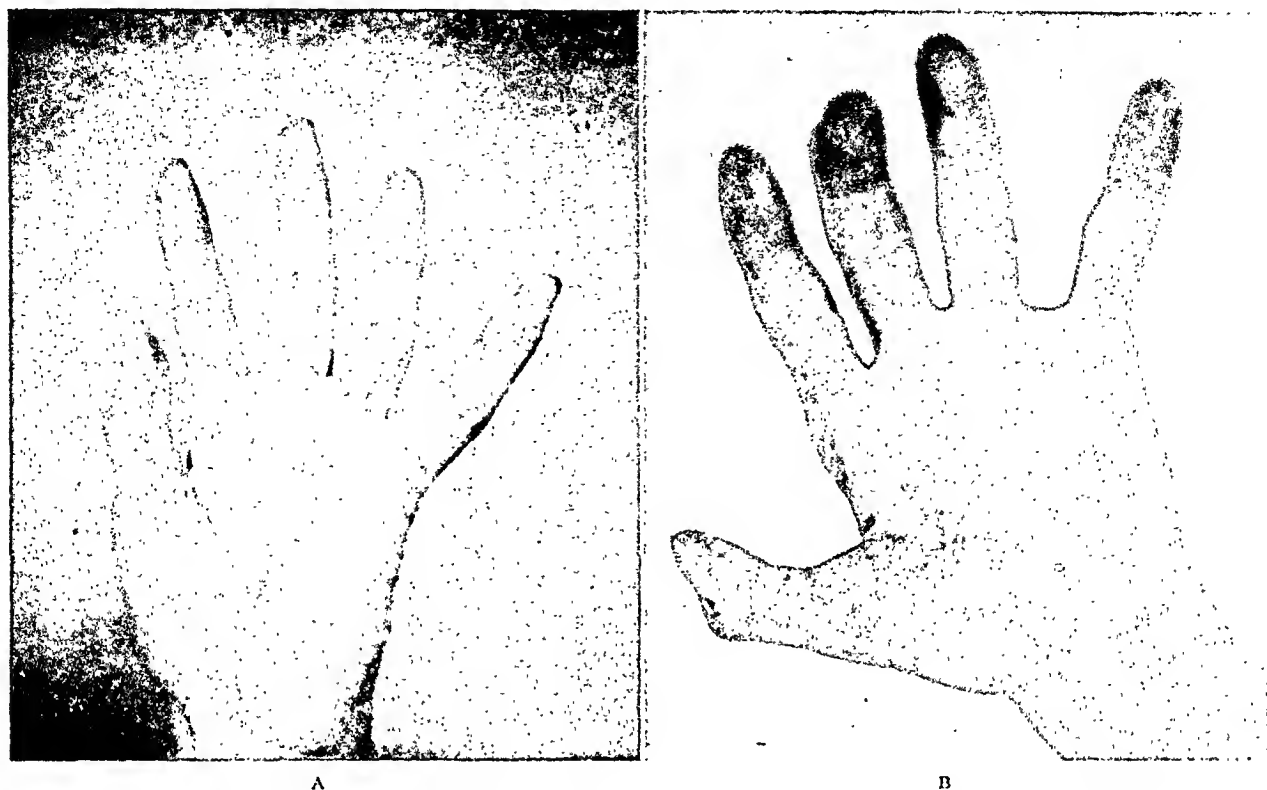


FIG. 5. A, scar contracture of thumb web following trauma. B, after excision and replacement with Wolfe graft.

the length of the hand and fingers. (Fig. 1.) It may be necessary to sacrifice some normal skin along the border in order to create a diamond-shaped defect. The purpose, of course, is to end with a staggered suture line that will not predispose to a potential subsequent postoperative contracture as healing occurs. (Figs. 4A, 4B and 10).

The use of pedicle flaps in the reconstruction of surface defects of the hands is limited to those cases in which it is necessary to replace the subcutaneous fat pad as well. These conditions arise chiefly when after excision of all scar tissue, the underlying tendon, bone or joints may become exposed. Often in cases of this type, future bone, tendon or peripheral nerve surgery may be anticipated. It therefore becomes necessary to cover lesions in this category with a pedicle flap so that such future surgery may be executed without fear of damaging the new skin covering and also that normal tendon and joint function may be expected without adherence to the new covering.

The use of pedicle flaps is more laborious and the covering somewhat bulky by comparison with free grafts. Hence the indications for this covering should be well defined. Whether a direct flap or a tubed pedicle flap is employed is of no difference in the net result. The chief advantage of the direct flap is that its use en-

tails a much more rapid procedure. Against this, the tubed pedicle involves more stages but is a closed wound which eliminates considerable potential contamination during the period of transfer. (Figs. 7A, 7B, 8A, 8B, 9A, 9B, 10A, 10B and 11.)

One final practical point deals with the selection of the donor site from which either a free graft or pedicle flap is taken. Always try to find an area that is free of hair when replacing defects on flexor surfaces. Patients complain endlessly over persistently growing hair in these skin transplants, even to the point wherein they frequently overlook an otherwise excellent functional and cosmetic result. The careful preoperative selection of the site from which the graft is to be taken will readily eliminate this annoying complaint.

#### SUMMARY

1. All incisions, suture lines and skin graft edges on hand and finger surfaces must be calculated so that they will fall either transversely or obliquely across the longitudinal axis.

2. Free full-thickness skin grafts give the best surface-bearing qualities and maximum degree of elasticity on flexor surfaces. Thick split-thickness grafts provide adequate covering for extensor surface defects and are pre-

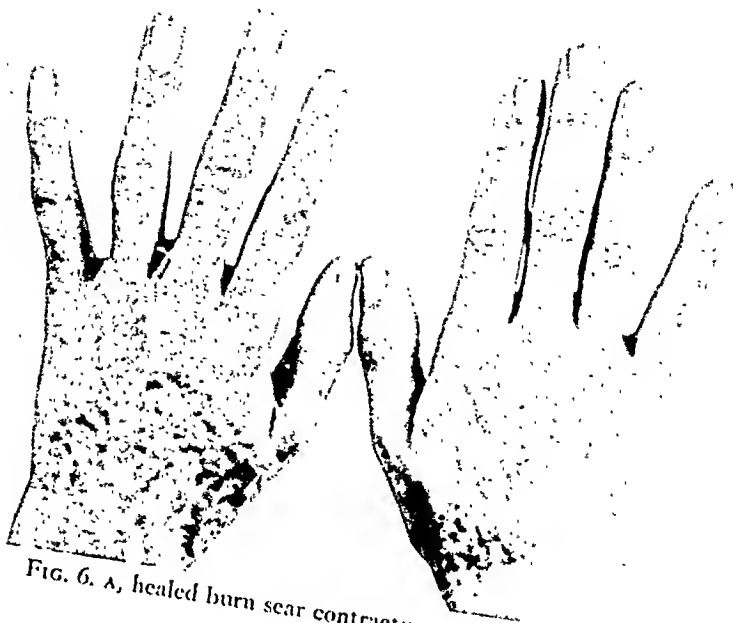


FIG. 6. A, healed burn scar contractures on extensor surfaces.

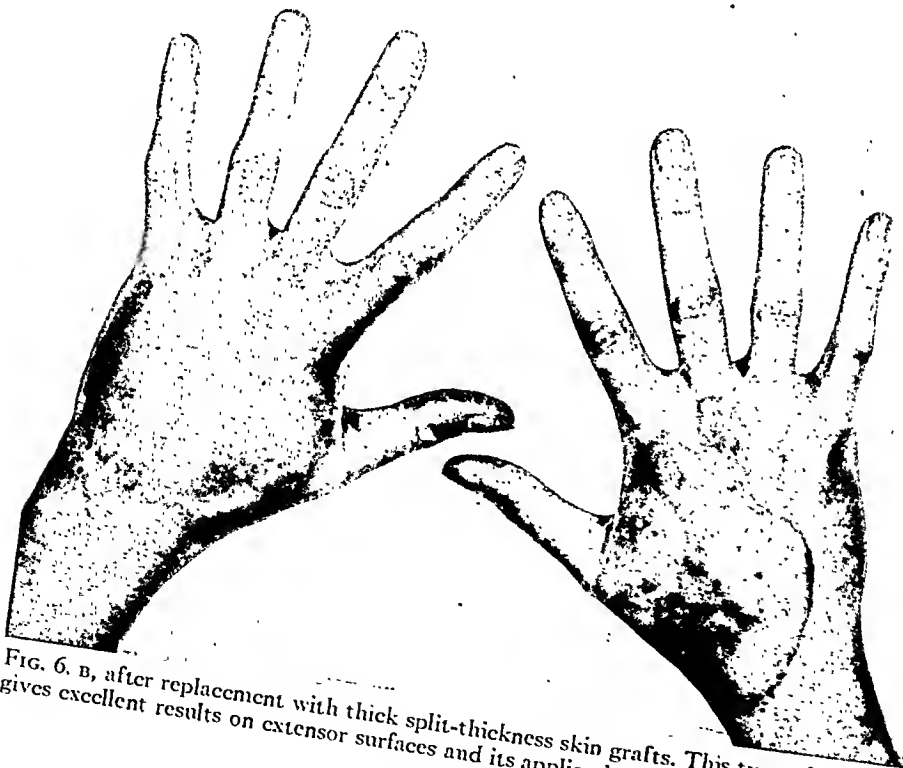


FIG. 6. B, after replacement with thick split-thickness skin grafts. This type of covering gives excellent results on extensor surfaces and its application involves simpler techniques.

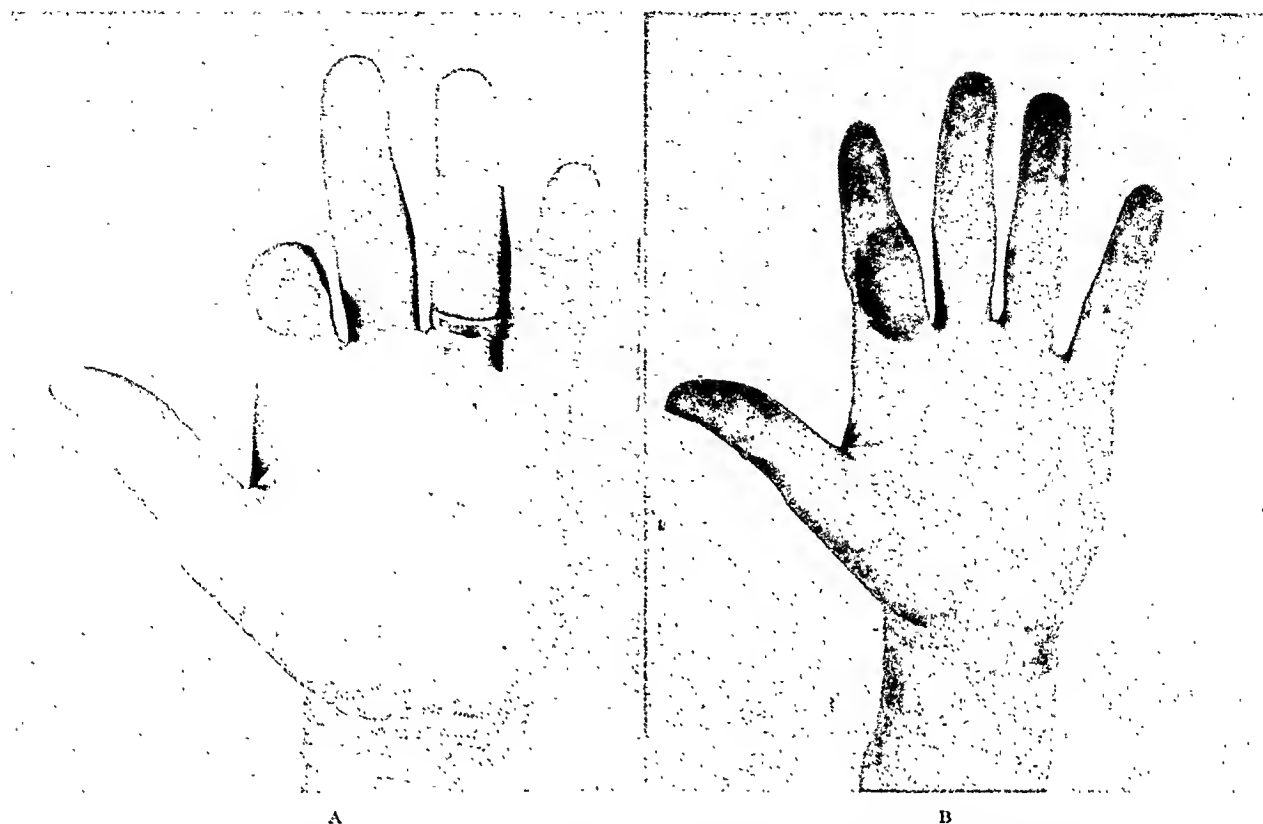


FIG. 7. A, deep flexion contracture of index finger. Excision of scar left tendons uncovered. B, correction following application of direct flap of skin plus subcutaneous fat. Functional result excellent but flap coverings are always more bulky.

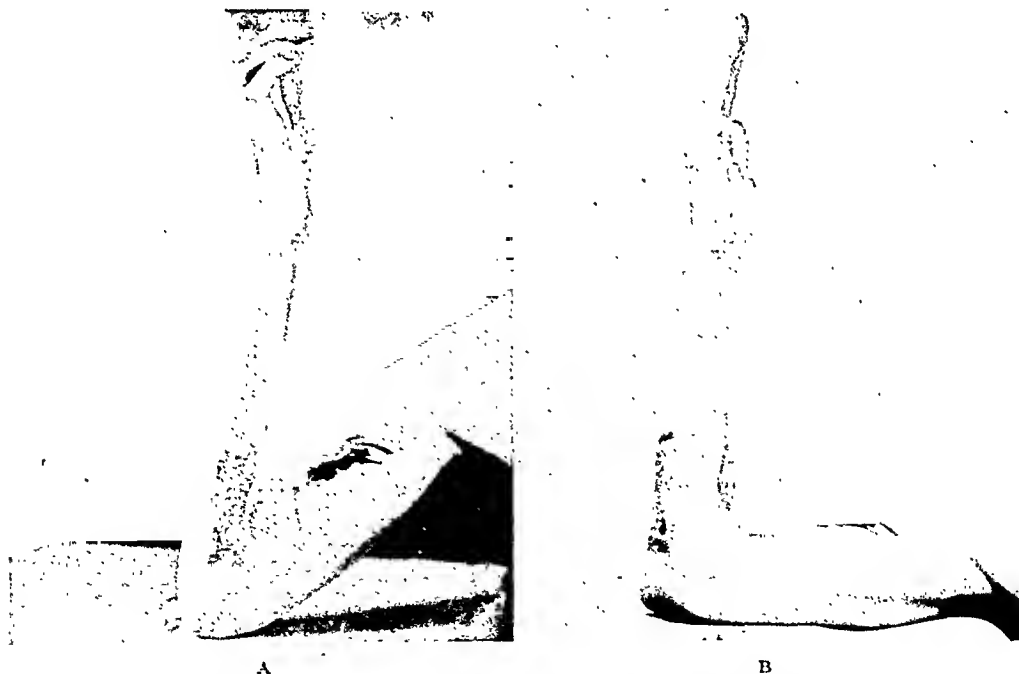


FIG. 8. A, flexion contracture of ring and little finger due to deep scarring of upper arm. Defect had been repaired elsewhere with pinch grafts with no improvement. B, scar excised and underlying muscles freed. Defect covered by adjacent border flap of skin and subcutaneous fat. Donor area from which flap was procured closed with split thickness skin graft.

ferred in this area because of the simpler technic associated with their use.

3. The use of pedicle flaps is reserved for

those instances in which it is necessary to carry subcutaneous fat with the skin grafts. This condition arises primarily in covering exposed





FIG. 9. A, healed deep wound with loss of skin and underlying extensor tendons to index, mid and ring fingers. B, after removal of all scar, the defect was covered by a direct flap of skin and subcutaneous fat. When healed and softened, this covering was re-elevated and the underlying tendon surgery completed.

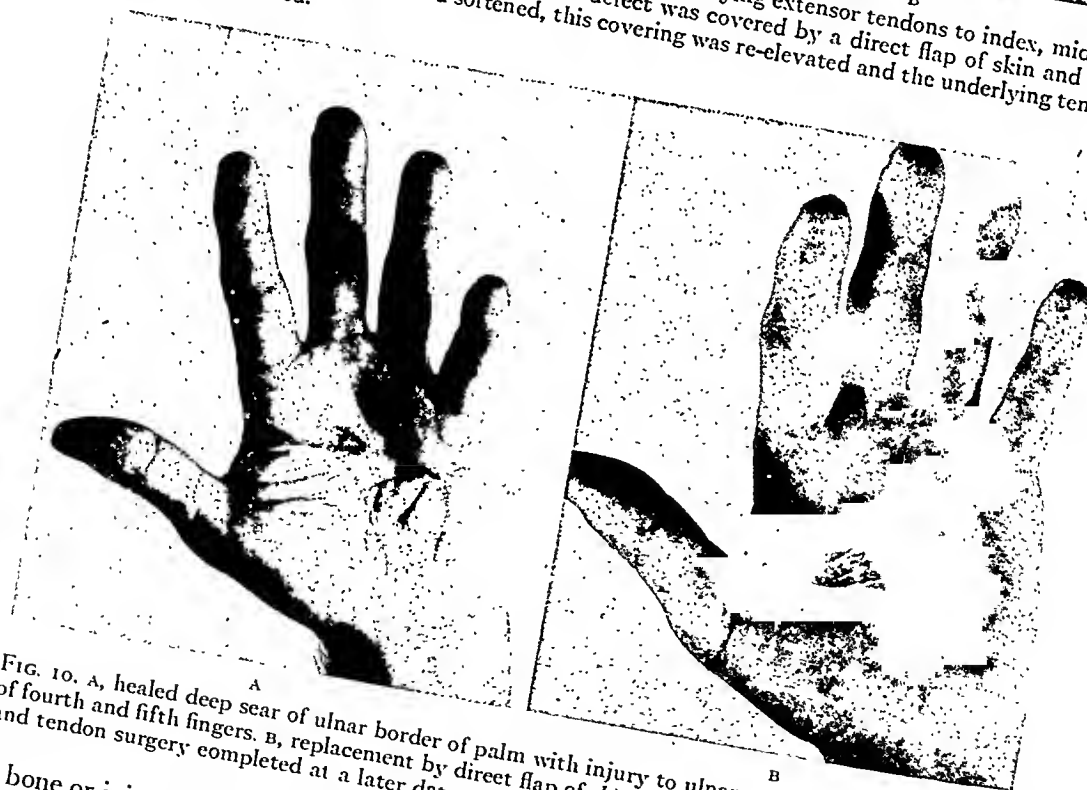


FIG. 10. A, healed deep tear of ulnar border of palm with injury to ulnar nerve and flexor tendons of fourth and fifth fingers. B, replacement by direct flap of skin and subcutaneous fat. Ulnar nerve and tendon surgery completed at a later date.

tendons, bone or joints, or when it is planned to re-elevate the graft at a future date for the purpose of carrying out subsequent tendon, bone or joint surgery.

4. When adequate skin and subcutaneous tissue is found in the border flaps after removal of a contracting scar, the use of the Z-plasty will frequently give rise to the most ideal final result.



FIG. 11. This problem was similar to that of Figure 9A. The defect, however, was covered by a previously tubed pedicle flap. This method is much slower than when direct flaps are used but has the advantage of offering closed surface areas at all points, thus eliminating contamination.

#### DISCUSSION

STERLING BUNNELL (San Francisco, Calif.): It was my good fortune to have seen and admired the work of Dr. Greeley at the Oakland Naval Hospital, and I am in complete agreement with his paper.

In furnishing cover to a hand we must consider: (1) liberation for nutrition, (2) freedom for complete motion and (3) special tactile surface. Skin applied as a mere patch falls far short of this.

A scar binds a hand and pulls from all directions, both surface and deep, spoiling the *nutrition*. Strangled nerves, blood and lymph vessels need liberation. If the cicatrix is in the wrist or forearm, which is the only source of supply to the hand, it pulls to itself from all directions, the effect being a veritable girdle even if the cicatrix covers only one-third of the circumference. To liberate we excise the complete scar, not leaving any cicatricial borders. The edges are then undermined until the skin retracts to its normal tension. At a later operation the deep scar is excised. Then the hand opens up, is liberated and can breathe again and thrive. All of the tissues will improve.

For *freedom of motion* there should be ample skin to cover the hand when in every possible position, and of freedom from any restricting scars. Grafted skin itself, whether by the free or pedicle method, expands enough to cover with normal tension, but it is the borders that contract and inhibit motion. If borders are placed along directions of push and pull, that is, if they cross flexion creases at or near

a right angle, they will be subject to the irritation of push and pull and so will contract to a hypertrophic cord limiting motion.

Some examples are as follows. A longitudinal scar along wrist, hand and fingers, whether volar or dorsal, will result in flexion contracture. A longitudinal scar on the back, front or side of the wrist will become a contracting cord as the wrist is a universal joint. A scar across the dorsum of the hand will contract and limit opposition of the thumb. A scar paralleling any web will make a flexion contracture inhibiting spreading of the adjoining digits. In a finger, a scar, if longitudinal, should be in the mid-lateral line. Only this line is free from push and pull. A laterovolar or laterodorsal longitudinal scar will, from motions of the finger, become a contracting scar. Skin grafts across the thumb cleft should be diamond-shaped, reaching from the hinge in front to the hinge in back so as to give free abduction of the thumb. All skin grafts, whether free or pedicle, should have their borders so placed that they are free from push and pull. If they are not, they should be zigzagged or waved. All this is because the hand is a mobile organ.

*The hand is a tactile organ.* Whenever possible the pulps of the first three digits, the eyes of the hand, should be covered by normal hand skin with its nerve supply to give stereognosis. This is done by transposing good skin in place of grafted skin or by filleting a finger to use its tactile pulp.

Dome-shaped pedicles are grotesque. They do not convey more skin as it is the borders that limit

motion. The surplus fat is parasitic. The pedicle requires two operations to be defatted. A pedicle flap to the hand should be flat relying on the rich circulation between the skin and the fat.

A final point is that hands are prone to stiffen. Any open wound stiffens a hand. Therefore, all pedicle skin flaps to hands should be rendered aseptic by either tubing them or closing them in with skin graft.

ALFRED W. FARMER (Toronto, Canada): I wish to express myself as being in complete accord with Dr. Greeley on all that he has stated in his paper, and after hearing the Master, there is not much left for me to say.

There was one point that I thought I should mention, however, and it was related not to a matter of technic and how one does the operation, but whether it should be done at all. In all hand cases, one sits down with the patient beforehand and goes over with him what he is going to do with that hand in the future, if possible. It may be badly injured and he will never return to his previous work at all. He will have to look for a new job, and there is no use doing a lot of unnecessary, high-class technical surgery on a hand that is not going to be any use to him for the job to which he is not going.

The next point that I was going to make has already been made by Dr. Bunnell, that is, direct shifts of pedicles to hands do not have to be left open. As a matter of fact, it is common practice, of course, to close them, either by a partial-thickness skin dressing or tube. By shifting the skin which is based on vessels, one can obtain a long pedicle for a direct shift without any trouble. For instance an abdominal flap of considerable size may be shifted directly if based on the superficial epigastric vessels.

In adduction contractures of the thumb, in my opinion, the most important joint to have free motion, is the carpometacarpal joint. This means that the incision in the web must be deep, very much lower than it is in a normal hand, because there may be some return of contracture. Into the web is placed a free graft or a pedicle graft, usually the latter.

Also, when that is done, it is necessary to free the muscles at their insertions, and it is not necessary in my opinion to reinsert them carefully by any complicated methods. There is enough reattachment with fibrous tissue to give one good power in adduction of the first metacarpal bone.

Attention must be paid in grafting to the webs of the fingers. Very often it is not possible in large grafts of the dorsal surface of the hand to graft so that in one stage the webs are satisfactory. If they are going to be satisfactory extra skin has to be inset, and those lines which are made in the webs must be long. I do not think there is anything at all against putting on the large graft and doing the

minor operations with a little extra skin at a later date.

Nothing was said about splinting of the hand, particularly in relation to the grafts on the anterior surface. Following replacement with free grafts on the anterior surface (and particularly in children) prolonged postoperative splinting in a position of extension is a necessity unless one is willing to undertake further operative procedures. When the patient goes home, and for many months after the grafts have been placed on the anterior surface, it is necessary for a child to wear a splint at night and probably for the rest period in the day, to hold the hand in full extension and not in the relaxed position, or shrinking will occur and the patient will have, particularly in the syndactylism cases, a return of contracture. One can accept that as inevitable if one wishes to do plastic operations on them at a later date.

Another point is that very often amputation of a finger or portion of a hand is indicated or dictated due to the economical point of view. To do a complicated series of operations for a contracture in the hope of getting a mobile useful hand or finger is not dictated when the whole situation can be settled by amputating that finger or a section of a hand, using the skin from the amputated finger either as a free graft for other portions of the hand or using it as a pedicle graft on the dorsal surface or on the anterior surface of the hand, as the case may be.

The little finger deserves special consideration in grafting of the dorsal surface of the hand in that the fifth metacarpal is so mobile and there is a tendency not to place the lateral scar far enough around on the side of the hand.

I think those are the main points I had in mind in discussing Dr. Greeley's presentation.

PAUL W. GREELEY (closing): I am sure that we all agree with both Dr. Bunnell and Dr. Farmer in everything that they had to contribute to the initial points that I brought forth.

I would like to re-emphasize the point that Dr. Bunnell made, that is, in removing the contracting scar, it all has to be removed, not just part of it but all of it. It has to be removed widely. I think many times an individual who is not too familiar with this type of surgery is apt to be a little bit timid and will remove only what he thinks is necessary to straighten out the fingers at that particular moment. However, if some scar has been left, it may cause the contracture to recur.

Even though one has to put on large grafts, it is of minor consequence. Large grafts have to be put on if the defect is large. In other words, always make certain that all of the scar is removed so that there will be no possible tendency toward contracture, irrespective of the amount of surface covering which you have to apply.

# OBSERVATIONS ON THE MANAGEMENT OF SUPPURATIVE ARTHRITIS OF THE KNEE JOINT\*

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THE purpose of this paper is to outline significant changes in the management of suppurative arthritis of the knee joint developing and based upon experiences during World War II in the Mediterranean Theater of Operations. Suppurative arthritis in this experience was superimposed on wounds and, therefore, the more comparable infections in the knee joint in civilian surgery are those following penetrating, lacerated and operative wounds. It appears, however, that the same principles are applicable to blood-borne suppurative arthritis.

Wounds involving the knee joint are serious wounds<sup>14</sup> not only because the damage at wounding is immediately prejudicial to subsequent function, but of greater importance because each is potentially a suppurative arthritis endangering life and limb. The reported results with suppurative arthritis of the knee joint during World War I and the early part of World War II revealed that the ravages of sepsis had often lead to death or amputation. Even if these had been avoided, many joints became totally destroyed resulting in fusion.

Frankau<sup>9</sup> records that in the British Army in the early stages of World War I, principally because of sepsis, the death rate from wounds of the knee joint was high and that 80 per cent of those complicated by fracture resulted in amputation. Later in that experience, the amputation rate fell to 25 per cent in 1916 and to only 7 per cent in 1917, while the death rate declined to 8 per cent. Buxton reporting 273 wounds of the knee joint treated in a base hospital during two Libyan campaigns in World War II cites incidences of 34.8 per cent suppurative arthritis, 4.4 per cent amputation and 1.8 per cent mortality. Ogilvie,<sup>20</sup> also of the British Army, while recommending free drainage for suppurative arthritis, based upon experiences in World War II, stated that the battle against sepsis was usually decided in four days and that, if in that time the septic

process was not controlled, amputation was necessary to save life.

The French in the last and this war accepted that once a suppurative arthritis was established, the joint was doomed and that life and limb were endangered. Fear of these dire consequences and a desire to provide adequate drainage had lead them to employ primary resection as a prophylactic measure in the severely damaged joint, recognized as especially vulnerable to sepsis, and secondary resection as a therapeutic measure for acute or chronic suppurative arthritis if the infection failed to respond quickly to long anterolateral incisions and thorough immobilization. Throughout World War II, French, Russian<sup>15</sup> and German<sup>25</sup> surgeons practiced resection extensively rather than risk the hazards of knee joint suppuration.

In American and English experience during and following World War I and the early part of World War II, the loss of life or limb had not been sufficiently frequent to warrant this radical almost prophylactic operative procedure. Wide incision, drainage and immobilization, and in World War II, the use of chemotherapy, had usually controlled the infectious process without death or amputation although residual function was often nil or greatly impaired. Pool,<sup>24</sup> in the Surgeon General's history of World War I, however, recommended resection for suppurative arthritis superimposed on a severely damaged joint.

Suppurative arthritis complicating wounds of the knee joint may be classified as potential and established. With every penetrating wound, the joint is contaminated and a potentially suppurative arthritis exists. Sepsis is not established, however, until there is septic decomposition of tissues destroyed by the agents of wounding or by the action of the infecting organisms with the formation of pus. Usually, several days and not merely a few hours are required for suppurative arthritis to become fully established, and then there is continuing destruction of articular cartilage and other

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intra-articular fibrocartilagenous structures by the proteolytic enzymes in the pus.

As was learned in World War I and relearned in World War II, the indicated management of potential or impending suppurative arthritis following wounds of the knee joint includes wide arthrotomy in the location which provides the maximum of intra-articular exposure, thorough excision of all devitalized articular cartilage and small fragments of bone, removal of foreign bodies and old blood clot, thorough irrigation of the joint cavity and closure of the joint space by suture of the synovia. Local and systemic penicillin therapy and thorough immobilization by a single hip spica or Tobruk splint were highly important adjuvants in avoiding established sepsis during World War II. This regimen held the incidence of established suppurative arthritis to a minimum, and it appears reasonable to state that this complication developed only when foreign material and intra-articular devitalized tissue were not or could not be thoroughly excised or when soft tissue loss was so great that the joint necessarily was left wide open.

In the early phases of this experience, not infrequently an infectious process was prevented by thorough intra-articular surgery; but because the time lag from wounding to surgery had exceeded eight hours, fear of enclosing a suppurative process led to the omission of synovial suture in order to provide continuous drainage. This was done despite the advice of Pool,<sup>29</sup> following World War I, who had stated that after the joint cavity had been thoroughly cleaned, closure of the synovial membrane was permissible and indicated for as long as twenty-four hours after injury. He attributed the poor results in wounds of the knee joint in the early part of World War I, in part, to "an undervaluation on the part of surgeons, of the resistance to infection which the synovial membrane of the joint offers." Others<sup>5,6,8,16</sup> also have emphasized apparent antibacterial properties of the synovial fluid.

When closure was omitted following adequate intra-articular surgery, a suppurative arthritis with continuing destruction of articular cartilage was usually avoided, but wound healing was slow and scar tissue formation about the suprapatellar pouch was excessive. The resulting limitation of motion appeared to exceed that which the severity of the wound seemed to warrant. With increasing

experience, closure of the synovia was employed in wounds of twenty-four or more hours' duration. Without doubt, the desire to close the joint, stimulated the surgeon to more thorough excisional surgery in the joint.

Other early observations indicated that, if gross dirt and foreign bodies were removed, the incidence of established suppurative arthritis varied with the extent of damage to the joint and the adequacy of the excisional surgery.<sup>11</sup> This complication seldom, if ever, was observed when the intra-articular bone and cartilage damage was minimal or absent and it was, indeed, rare, when the damage was moderate if surgery was adequate. With only moderate damage and inadequate intra-articular surgery, however, sepsis with destruction of the joint often followed. Compound comminuted fractures of the patella or condylar fractures of the femur or tibia were a likely source of such a septic process. With severe intra-articular damage, septic arthritis was the rule. In each, the joint had been destroyed at wounding and an ankylosed knee in the functional position was the best that could be expected. Even though the joint was destroyed and prolonged suppuration with toxemia was likely, resection of the joint was not considered.

During the phase of these observations, the therapy of suppurative arthritis was based upon wide parapatellar incisions for continuous drainage, immobilization and antibiotics as had been recommended by practically every authority,<sup>1,3,10,13,18,19,20,21,26</sup> reporting on this subject, prior to and during the early phases of World War II. Fortunately, the regimen was usually successful in preventing loss of limb or life. In some, the infectious process subsided without further septic destruction of the articular surfaces of the femur and tibia but scar formation about the incisions appeared to limit excessively the subsequent function. In many others, however, there was lingering sepsis, slow destruction of the joint<sup>23</sup> and low grade toxemia. In the severely damaged joints with suppurative arthritis, drainage was always prolonged and there was usually evidence of chronic sepsis. More favorable results appeared possible.

Subsequently, the therapy of suppurative arthritis was revamped upon the basis that, with foreign bodies and material removed, suppuration within the knee joint developed and persisted only when there was retained de-

vitalized articular cartilage, a structure of recognized avascularity and low resistance to infection, and that adequate and complete drainage of fluid from the knee joint was not surgically feasible, drainage incisions serving only as safety valves to prevent the accumulation under pressure of fluid within the joint. Since drainage was often ineffective, it did not prevent the continuing destruction of articular cartilage and the menisci and, in addition, continuous drainage impaired any antibacterial action of the synovial fluid. Moreover, drainage openings left the joint open to secondary invaders and jeopardized the nutrition of the articular cartilage. Finally, the subsequent range of knee joint motion was excessively impaired even if sepsis was controlled.

It was, therefore, concluded that continuous drainage of the knee joint cavity was not only ineffective but was contraindicated and that the therapy of established suppurative arthritis should be based upon the same principles which had been successfully employed in the management of potential or impending infection. To that end, the following regimen was applied in the presence of impending or established suppurative arthritis regardless of the time lag since wounding or the duration of the sepsis.

The joint cavity was exposed by adequate medial and/or lateral parapatellar incisions. Any retained foreign bodies were removed, of course, and all devitalized articular cartilage destroyed at wounding or by sepsis was excised. In sepsis of several days' duration, the menisci were often soft and friable and, if so, these too were excised. Old blood clot and exudate were cleaned from the joint cavity. Only healthy living tissue remained. Thereafter, the joint synovia was closed. In the presence of soft tissue loss, rotation of a flap of skin or a fascial graft was employed to achieve a closed joint. Only when hope of future function of the joint was abandoned was it left open. Penicillin solution was instilled into the joint cavity, and, obviously, the closed joint aided in the retention of this antibacterial agent. The extremity was then well immobilized in a single hip spica or, on occasion, a Tobruk splint. Penicillin therapy systematically was initiated.

Thereafter, any reaccumulation of fluid in the joint was aspirated through a window in the cast at intervals of twenty-four to forty-eight hours with the reinstallation of penicillin. As a rule, however, little fluid reaccumulated.

When danger of continuing sepsis (which would have resulted only from incomplete intra-articular surgery) was past, usually five to seven days later, the remaining soft part wound was sutured. When the wound was healed sufficiently, usually about twelve to fourteen days after the arthrotomy, immobilization was discontinued in favor of mobilization in balanced suspension using a Thomas splint with Pierson attachment. Active and passive movement of the knee joint was gradually increased.

This regimen, when the intra-articular damage did not preclude its application, was highly successful in reducing morbidity and predisposed to the maximum return of function of the extremity. In those joints so severely damaged at wounding or by the septic process that complete excision of all devitalized tissue precluded subsequent function of the joint, the sepsis was eliminated and what is believed to be the optimal result was achieved by resection of the joint. These resections were, in effect, only thorough excision of dead and devitalized bone and cartilage which had been destroyed by the missile of wounding or by the infectious process. The amount of dead tissue predetermined the extent of excision and, therefore, the resulting shortening of the extremity. The lower end of the femur and the upper end of the tibia were carefully held in approximation thereby eliminating the dead space and predisposing to rapid union and wound healing.

Several illustrated cases are herewith reported as typical of this experience:

#### CASE REPORTS

**CASE 1.** This patient received a penetrating wound of the left knee on medial side on July 1, 1944. Several hours after injury, the knee joint was opened through a medial parapatellar incision and the foreign body embedded in the medial femoral condyle was removed. The joint capsule was sutured. Penicillin was instilled in the joint, systemic penicillin therapy was initiated, and a toe-to-groin plaster cast was applied.

When observed several days later in a base hospital, the knee was painful and swollen and pus was oozing from the incision. Through a large needle, an effort was made to irrigate the joint and penicillin was instilled. The patient was running a low grade septic course, with temperature ranging from 98° to 101.4°F.

Thirteen days after injury, the temperature was 101°F., the knee was swollen, boggy and tender, a



FIG. 1. A, Case 1, photograph of the interior of the knee at the time of the second arthrotomy. The edge of the damage to the articular cartilage is visible. Note the intense hyperemia. B, in three weeks the operative wound is healed and the joint is normal in size.

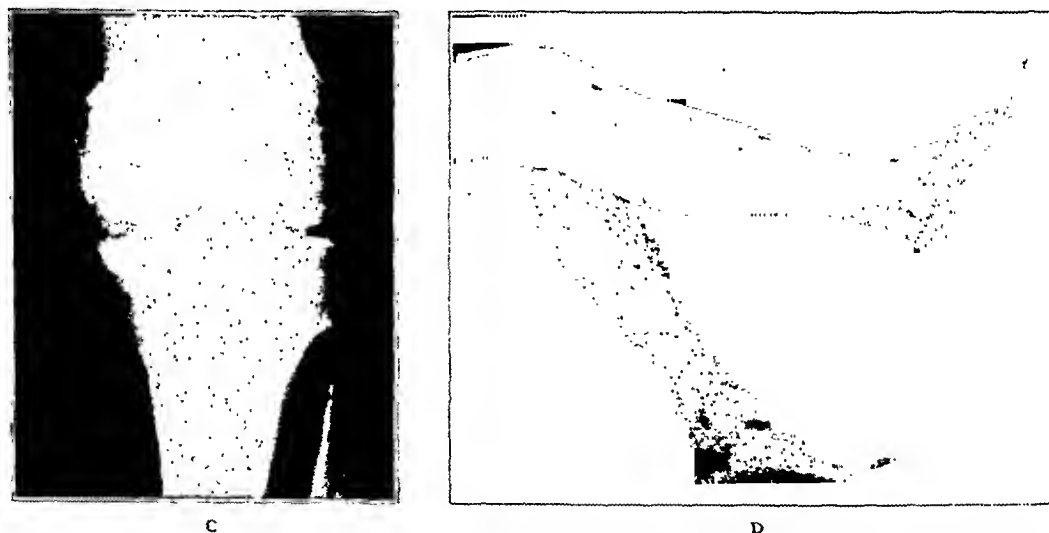


FIG. 1. C, Case 1, reproduction of anteroposterior roentgenogram taken nine months later. The extent of condylar damage is demonstrated. D, the range of knee motion nine months later. Complete extension was possible but is not shown here.

seropurulent discharge leaked from the joint and maggots crawled from the wound.

The joint was reopened and the old wound was extended. Maggots again were present. A piece of woolen cloth and from beneath it a devitalized area of articular cartilage about 1 inch in diameter depressed into a defect in the medial femoral condyle were removed. The defect was trimmed evenly and the joint was thoroughly inspected for further damage but none was found. The medial meniscus was dull in appearance but was not friable, so it was not removed. After thorough irrigation, the synovial membrane of the capsule was closed and the joint was filled with penicillin. Immobilization was achieved by means of a Tobruk splint.

On the second and third days after operation, a

small amount of synovial fluid was aspirated and the joint was irrigated and filled with penicillin through a large needle. On July 19, six days after the surgery, the soft part wound was sutured. Quadriceps exercises were instituted.

On August 7 the wounds were healed and movement of knee joint was started. All joint reaction subsided and, five weeks after surgery for the suppurative arthritis, the active range of motion was about 15 degrees. The patient was then evacuated to the Zone of the Interior with removable splinting for use at night as a precaution against flexion contracture.

At a check-up examination made on April 5, 1945, nine months later, the patient was observed with all wounds healed and an active range of knee



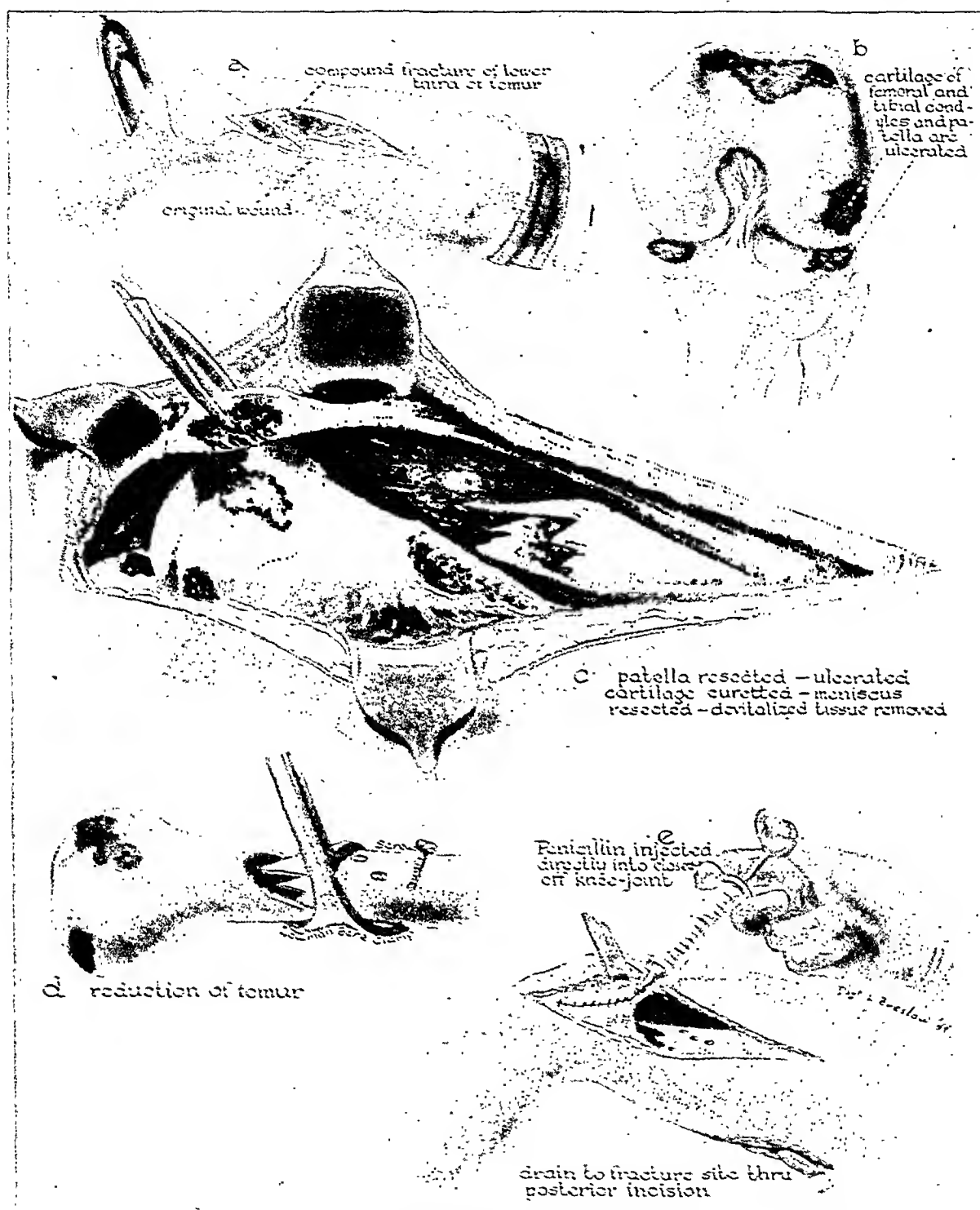


FIG. 2. Case 11. Artists's conception of the surgical procedure carried out on April 6th. The extent of bone loss is not shown. (From *Ann. Surg.*, 123: 249, 1946.)

motion from full extension to 100 degrees. The knee was reasonably stable and the patient had no complaint other than his restricted motion.

**Comment.** This case illustrates the necessity for and the effectiveness of an aggressive surgical program in early knee joint sepsis. Obviously, drainage alone would not have controlled the sepsis or have prevented complete destruction of the joint. The excisional surgery

was the most important factor in the achievement of excellent result. It may be noted that, in the presence of inadequate initial surgery and with devitalized tissue retained, penicillin therapy *did not prevent sepsis*.

**CASE 11.** A soldier received a high explosive shell fragment wound on February 20, 1944, with a compound comminuted fracture of the left femur in the distal third. After transfer to a base hospital

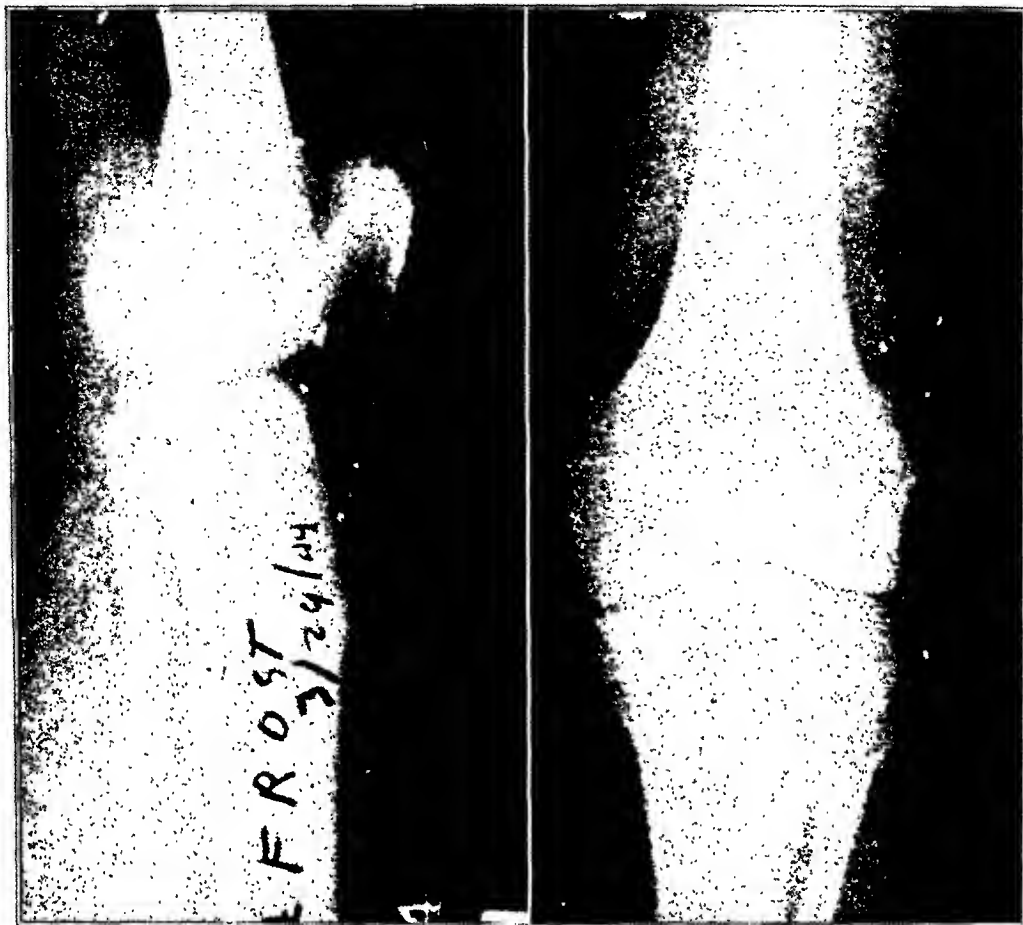


FIG. 3. A, Case III. anteroposterior and lateral roentgenograms show the multiple foreign bodies in the joint.

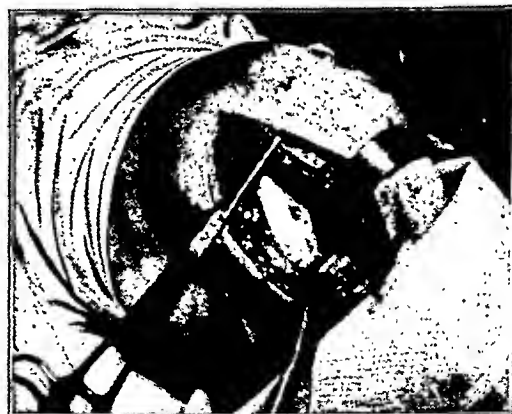
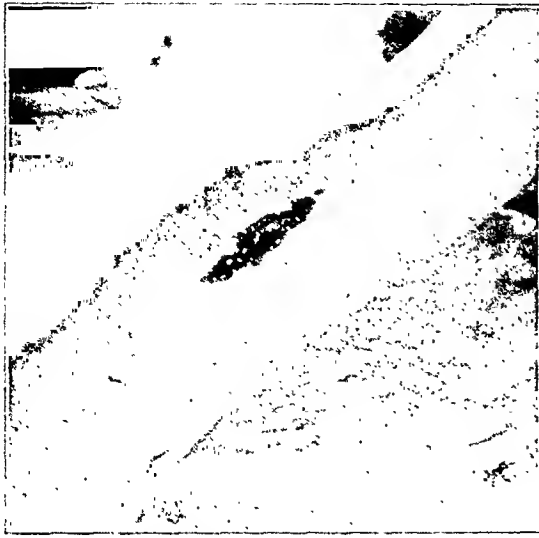


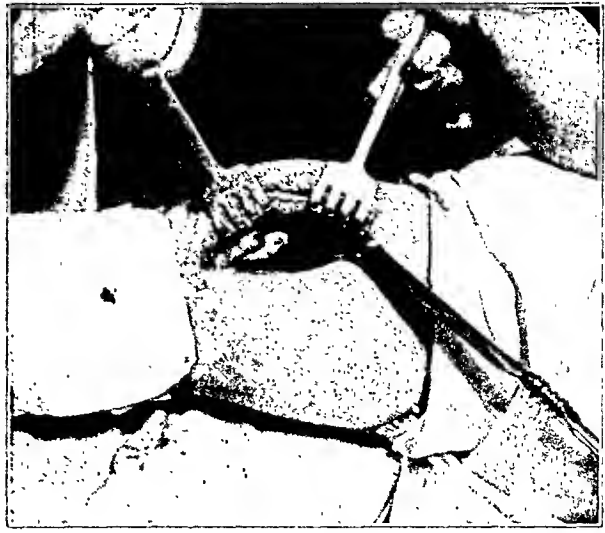
FIG. 3. B, Case III. photograph of the bulging knee, before surgery, on the fourteenth day after injury. C, several areas of damage to the articular cartilage are revealed by the medial arthrotomy incision.

and the institution of skeletal traction, the wound became grossly septic and it was obvious that the left knee joint was swollen. Following the aspiration of purulent material, the joint was drained by bilateral parapatellar incisions and the fracture

site was drained by extending proximally the compounding wound over the lateral surface. Thereafter, the patient ran a low grade septic course. Purulent drainage from the fracture site and incisions of the knee continued.

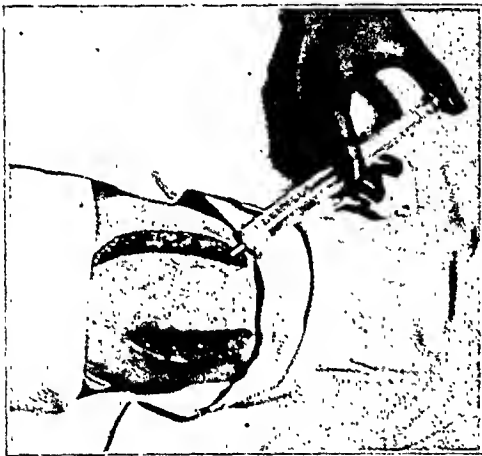


A



B

FIG. 4. A, Case IV, shows the swollen joint and the granulating wound, with pus draining from the opening in the center, as they appeared in the operating room on October 21, 1944, fifteen days after the wound had been received. B, photograph of the medial arthrotomy incision. Inflamed synovial membrane and the partially necrotic cartilage of the comminuted patella are poorly visualized. The small piece of woolen cloth is shown on the gauze at the left of the incision. The quadriceps pouch was filled with a coagulated fibrinous exudate.



C



D

FIG. 4. C, Case IV, following removal of the patella and cleansing of the joint, the synovial membrane of the arthrotomy incision and the defect in the old wound were sutured (plus a few sutures in the tendon). The joint was filled with penicillin. D, the fragments of patella, some of the fibrinous exudate and the bit of cloth removed from the joint are shown.

Six weeks later, after penicillin therapy was instituted and 1,500 cc. of blood were given, abscesses in the proximal thigh were drained by liberal incisions and posterior drainage of the fracture site was established.

Five days later, through the compounding wound, the comminuted fracture was stabilized in reduction by four screws and the knee was opened by extending the incision distally. The articular cartilage of the patella was soft, eroded and detached. There was spot erosion of the articular cartilage of the femur and tibia at the points of contact and where the patella had rested upon the femur. The patella was removed, the edges of eroded cartilage were trimmed and the bases were

curetted. The joint was thoroughly irrigated, closed and filled with penicillin.

All reaction about the knee subsided and the wounds of the thigh healed slowly. Two weeks after surgery on the knee joint, passive motion through a 10 degree arch was carried out daily until the patient was evacuated to the Zone of the Interior in a hip spica in May.

The fracture of the femur united but it was necessary to remove two small sequestra and the screws before wound healing was achieved. Knee motion was limited to about 15 degrees. Unfortunately, in late December, of 1944, he suffered a refracture of his femur at the site of bone loss. Thereafter, immobilization was quite prolonged.



FIG. 4. E, Case IV, the skin has been sutured and the joint resplinted (October 26th). F, demonstrates the range of active painless motion of the knee on November 17th. Quadriceps power was sufficient to extend the knee but a hand held the foot for the photograph.

**Comment.** The excisional surgery within the knee joint followed by closure and adequate penicillin therapy prevented the continuing destruction of the articular cartilage of the joint. Ten to 15 degrees of motion was preserved. This appears preferable to the fusion which probably would have occurred with only drainage of the joint. It appears reasonable to state that if the low grade suppurative arthritis had been his only problem, a greater range of motion in the knee would have been obtained. The range of knee motion following compound comminuted fractures of the lower end of the femur is always markedly restricted particularly when prolonged immobilization is necessary.

**CASE III.** This patient was wounded at Anzio on March 29, 1944, by multiple small high explosive shell fragments. It was the judgment of the surgeon in the forward hospital that arthrotomy would not be effective and so the wounds were not débrided.

He was received in the base nine days later with a temperature ranging from 101° to 102°F. The knee joint was painful, hot and swollen, and pus oozed from the multiple wounds. Penicillin therapy was initiated.

The knee joint was opened through a medial parapatellar incision and the bloody, pus-filled joint was thoroughly irrigated. Several embedded metallic foreign bodies were removed from the articular cartilage of the femur. The medial meniscus was friable and partially devitalized so it was excised. Through a lateral parapatellar incision, areas of devitalized articular cartilage

and a friable lateral meniscus were removed. After thorough irrigation, the synovial membrane of each incision was sutured, the joint was filled with penicillin and the extremity was immobilized by hip spica.

On each of the next four days, through a window in the cast, the synovial fluid was aspirated and the joint was irrigated and filled with penicillin daily.

All joint reaction subsided and nine days after the surgery for suppurative arthritis, the skin was sutured. The wounds healed and active knee motion was instituted. On May 8th, a little over five weeks after the wounds were received and four weeks after the surgery for the suppurative arthritis, the range of active knee motion was 30 degrees. A later report following his evacuation to the Zone of the Interior was not received but it is believed that he obtained a range of motion adequate for ordinary function.

**Comment.** The sepsis following lack of initial surgery was controlled by excision of the intra-articular foci before the undamaged articular cartilage was digested and destroyed. Drainage incisions probably would have been ineffective. The program for suppurative arthritis was effective in salvaging the joint.

**CASE IV.** This soldier received a penetrating wound of the right knee anteriorly with a compound comminuted fracture of the right patella. Ten hours after injury the joint was opened by enlarging the compounding wound and the foreign body was removed, the joint irrigated and the capsule closed. The comminuted patella was not

removed and the intra-articular structures were not thoroughly inspected. Penicillin was instilled into the joint and systemic penicillin therapy was initiated. A long leg cast was applied.

He was received in the base hospital five days later where penicillin therapy was continued. The patient ran a low grade septic course with temperature ranging from 99° to 101°F. The knee was painful, swollen, boggy and tender.

Fourteen days after injury, the joint was opened through a medial parapatellar incision. A small piece of woolen cloth was removed from the joint. The severely comminuted patella was excised. The cartilage of the patella was greyish yellow in color and one fragment appeared necrotic. Gelatinous, fibrinous exudate was cleaned from the joint and the suprapatellar pouch.

After thorough irrigation, the synovial membrane was closed and a few sutures were placed at the quadriceps tendon. The old wound was excised to the depth of the fascia and an opening into the joint was closed by suture. The joint was filled with penicillin and a Tobruk splint provided immobilization. On each of the next four days, the joint was irrigated through a large needle and filled with penicillin.

Five days after surgery for suppurative arthritis, the skin of each wound was sutured. Immobilization was continued until eighteen days after surgery. Then active knee motion was begun and only night splinting was used. Five and one-half weeks after surgery, there was no reaction about the joint, quadriceps power was fair and there was 45 degrees of active knee motion.

*Comment.* A compound comminuted patella was frequently the nidus of knee joint sepsis. The traumatized cartilage remains and obviously the joint remains open. The ineffectiveness of penicillin therapy when excisional surgery is inadequate may be noted. In this case, removal of the comminuted patella and thorough cleansing of the joint of all foreign material, blood clot and pus before proteolytic digestion of the articular cartilage began followed by adequate immobilization and penicillin therapy led to a functioning joint. It is believed that a much less desirable result would have been obtained by mere drainage incisions.

**CASE V.** This soldier was wounded on January 8, 1944, by high explosive shell fragments. He received a traumatic amputation in the upper third of the left thigh and a compound comminuted fracture of the medial condyle of the right tibia which extended into the knee joint. Forty hours after injury, the traumatic amputation was com-

pleted by the guillotine method and minimal débridement of the penetrating wound of the right tibia was performed.

He was received in the base hospital on January 21st, eleven days after his injury. The amputation stump was clean but there was profuse drainage from the upper tibia. Thereafter, signs of a suppurative arthritis of the knee developed and bilateral parapatellar drainage incisions were made. Despite penicillin therapy and repeated blood transfusions, sepsis continued with the temperature ranging up to 102°F. Abscesses developed in the proximal and mid-thigh and these were drained. Later roentgenograms revealed septic destruction of the articular surfaces of the femur and tibia.

He was seen in consultation on March 23rd, over two months after his injury. He appeared quite ill and amputation was considered as a lifesaving measure. He had been kept alive with a total of 4,500 cc. of blood.

During the next two days, an additional 1,500 cc. of blood was given and on March 26th, surgery for this extensive suppurative arthritis was performed. The old incisions were extended proximally in order to drain abscesses of the thigh and another abscess in the calf was incised. A long medial parapatellar incision and reflexion of the patella disclosed that the joint cartilage, including that of the patella, had been totally destroyed by the septic process. The old articular surfaces and the eroded underlying bone was excised and the patella was removed. The wounds were thoroughly irrigated. The bones were held in approximation by a wire loop passing through the anterior portions of the femur and tibia. The old wound edges were excised but none were sutured. A hip spica provided immobilization.

During the next two days 1,500 cc. of blood were given and penicillin therapy was continued. The only temperature rise above 100°F. during the first five days after operation occurred following a mild transfusion reaction.

On April 1st, six days after the resection of the joint, the hip spica was removed in the operating room and an old blood clot was irrigated away. The wounds were partially sutured with drains to the back of the old joint space and to the calf abscess. On this day, 1,500 cc. of blood was given. On April 7th, six days later, an additional incision in the calf for drainage of this abscess was necessary and on that day, 500 cc. of blood was given. Thereafter, all wounds granulated to almost complete healing and the knee fused to stability. In late April, he was transferred to a Canadian hospital and since then follow-up information has not been available. At that time there were no sinuses to the bone and the wounds were healing. It may be of interest that he received a total of 12,500 cc. of blood over a three months' period.

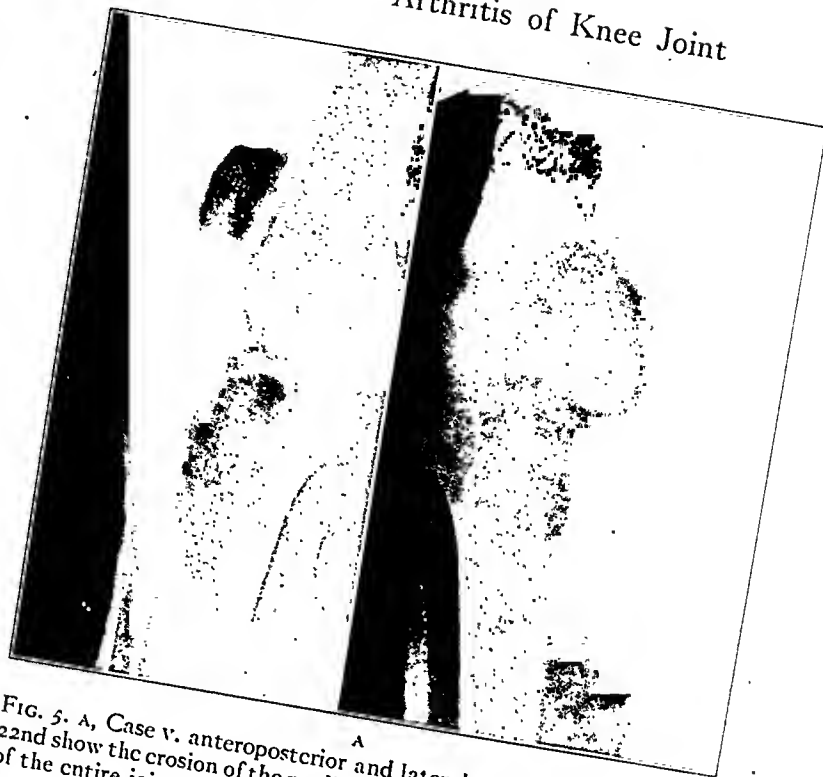


FIG. 5. A, Case v. anteroposterior and lateral views taken on March 22nd show the erosion of the medial tibial condyle and the destruction of the entire joint.

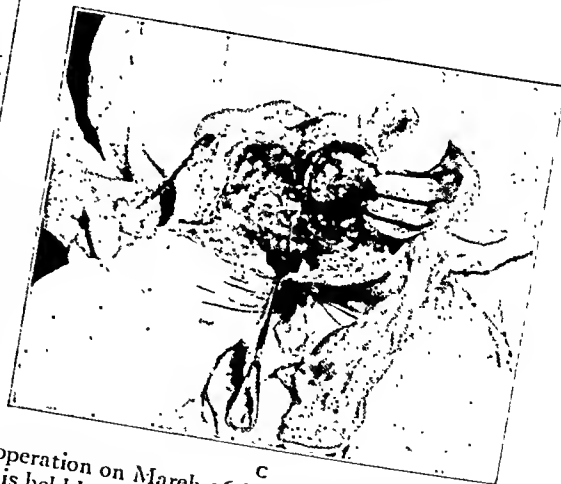


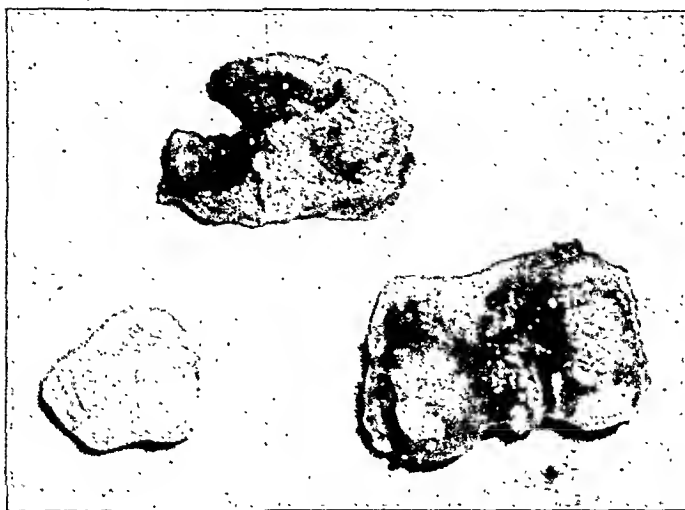
FIG. 5. B, Case v. photograph of the joint exposed at operation on March 26th. The patella has been removed. For photographic demonstration the patella is held beside the destroyed femoral condyles. C, photograph of the resected joint. Shortening in this case was of no consequence because of amputation of the opposite leg.

**Comment.** The ravages and potential dire consequences of knee joint sepsis, the ineffectiveness of drainage incisions, particularly after septic destruction of articular cartilage, the salvage of a limb and possibly of a life by resection of the knee joint are here illustrated.

**CASE VI.** This soldier received a penetrating wound of the left knee on October 18, 1944. A few hours later in a forward hospital, foreign bodies were removed through a small incision. The synovia

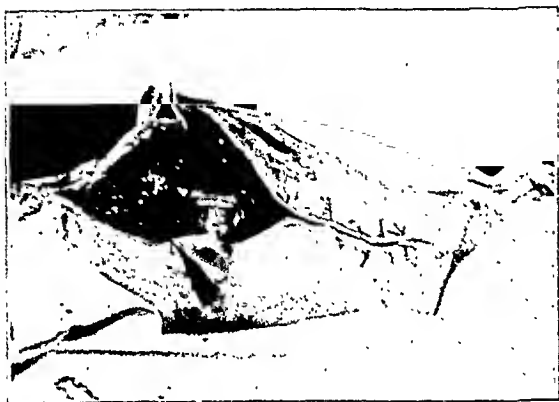
was closed, penicillin was instilled and a hip spica was applied. Systemic penicillin therapy was instituted.

In the base hospital where he was received a few days later, it was assumed that because the foreign bodies had been removed, intra-articular surgery had been thoroughly performed. Signs of a suppurative arthritis developed and drainage through the wound began. The recommended therapy of re-arthrotomy and thorough intra-articular surgery was not carried out. There was continuing destruc-



D

FIG. 5. D, Case v. the dead, infected tissue has been excised.



E

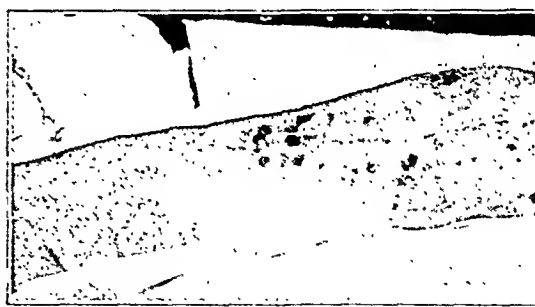


F

FIG. 5. E, Case v. the medial wound has been partially closed with drainage (April 1st). F, shows closure of the lateral wound and drainage of the calf abscess (April 1st).



G



H

FIG. 5. G, Case v. the medial and lateral wounds have almost healed (no sinuses) on May 23rd. H, the medial and lateral wounds have almost healed (no sinuses) on May 23rd.

tion of the joint surfaces and the patient became quite ill.

He was seen in consultation in December, two months after his injury, and resection of the joint was advised as a means of overcoming continuing sepsis and reducing morbidity.

On January 6, 1945, three months after wounding, the joint was resected and the fragment ends were stabilized in approximation by use of the external skeletal fixation apparatus over which a

hip spica was applied. All wound edges were excised but they were not sutured until a delayed surgical procedure three weeks later. The wounds healed and he was evacuated to the Zone of the Interior in a hip spica.

He was observed on March 28, 1945, in a named general hospital in the United States. All wounds had been soundly healed on admission. It appeared that the femur and tibia were uniting by bone in the optimum position. There was shortening of





FIG. 6. A, Case VI. roentgenograms made soon after injury revealing moderate intra-articular damage.



FIG. 6. B, Case VI. the septic destruction of the joint two months later.

about 3 inches, resulting not from the resection but from bone destruction by the septic process. Resection was an alternative to amputation.

#### CONCLUSIONS

1. The nidus of continuing sepsis following wounds of the knee joint is usually traumatized, devitalized, articular cartilage. Blood clot, coagulated exudate or devitalized menisci provide further pabulum for sepsis.

2. The keystone of the elimination of the septic process is the complete surgical excision of tissue destroyed at wounding or by the septic process.

3. Thorough continuous drainage of the

knee joint is not surgically feasible or effective. Drainage incisions serve only as safety valves. Despite them, intra-articular suppuration can persist with continuing proteolytic digestion of articular cartilage.

4. Moreover, continuous drainage of fluid from the joint is contraindicated because any antibacterial action of the synovial fluid is handicapped, the joint cavity is open to secondary invaders, nourishment of articular cartilage may be reduced and excessive scar formation may be anticipated.

5. Therefore, following adequate cleansing of the joint of all potentially septic material,



FIG. 6. c, Case VI. the resected joint several days after operation.

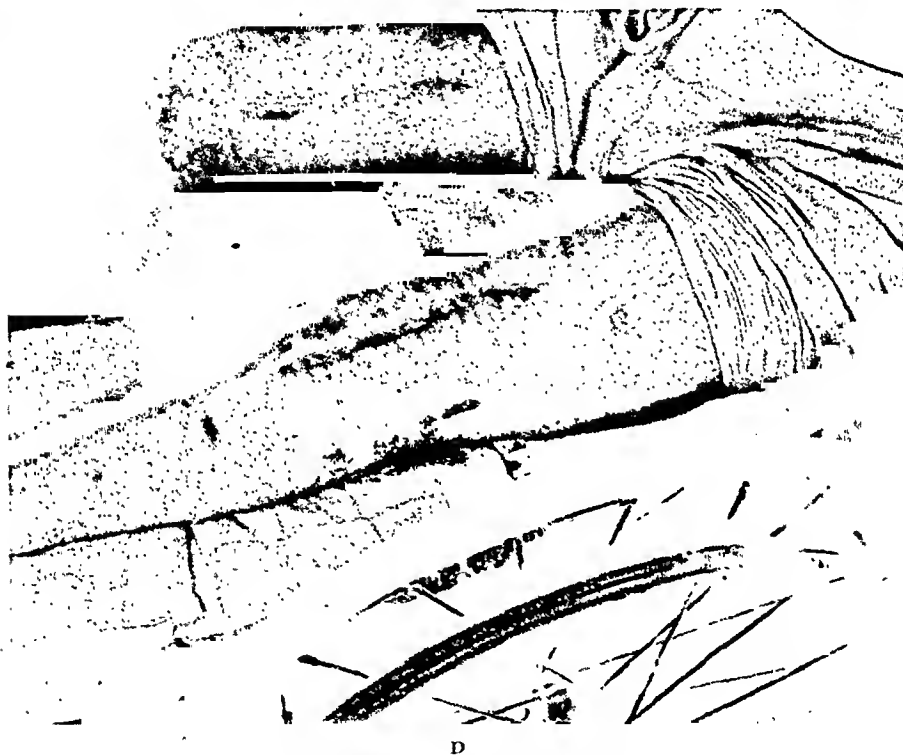


FIG. 6. d, Case VI. the healed wounds and stable knee a few months later.

the cavity is closed, usually by suture of the synovia, if future motion is anticipated.

6. When the damage at wounding or by sepsis precludes subsequent function, the morbidity can be reduced and the best obtainable functional result may be secured by resection of the joint.

7. This regimen is made possible without fear of grave complications by the availability of effective antibacterial agents, such as penicillin, to protect living tissue from invasive infection.

8. In those instances in which suppurative arthritis responds to open drainage, the open drainage was not necessary and the recommended regimen would have reduced morbidity and lead to a better result in less time.

9. It appears reasonable that, in blood-borne suppurative arthritis not responding to repeated aspiration, immobilization and antibiotics, a regimen of therapy including intra-articular débridement of tissue destroyed by sepsis, removal of coagulated exudate and hematoma, closure of the joint, immobilization

and local and systemic penicillin therapy may be the means of eliminating the septic process.

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## DISCUSSION

HARRY B. MACEY (Temple, Tex.): I think this is quite a timely presentation and I know of no one better equipped to present this subject than Dr. Hampton, who had an extensive experience in the Mediterranean Theater. I am heartily in accord with everything that he has said and I merely want to re-emphasize some of the points that time prevented him from stressing.

Most of the things I will say are commendation of the paper. The problem of treating suppurative arthritis of the knee joint, as he pointed out, is really two-fold: one is the adequate surgical care of the wound; second, the use of antibiotics, chemotherapy and penicillin. They must complement each other. The surgery must be adequate, but, as mentioned by Dr. Hampton, not stressed; the joints should be widely opened and a thorough débridement done for the joint to be in a receptive mood for the chemotherapy and the penicillin which is instituted later. It is impossible to expect a drug such as penicillin, or a sulfonamide, transported in the blood stream to get into devitalized tissue. Therefore, all devitalized tissue should be thoroughly excised.

Secondly, by closing the capsule the traumatized area is going to be bathed by a fluid with a high concentration of penicillin and sulfa.

I think we see this borne out in the blood-borne suppurative arthritis. I have seen very few, but they were treated very satisfactorily with repeated aspiration, injection of penicillin into the knee joint and giving penicillin and sulfa drugs systemically.

I had the experience of treating one patient with a double infection, both staphylococcus and streptococcus. Response was not satisfactory with penicillin alone; however, with the addition of sulfadiazine on about the fourth day improvement was noted. He made a complete recovery and had a normal joint, that is, from early observation.

Clinically, there were no x-ray changes and no symptoms. Therefore, I would be inclined to delay surgery in the suppurative arthritis from blood-borne disease for many days, in the hope that surgery may be entirely avoided.

Again, I want to say that I appreciated hearing this excellent paper and enjoyed discussing it.

OSCAR P. HAMPTON, JR.: Time did not permit me to emphasize the place of resection of knee joints destroyed by sepsis as I desired. There definitely appears to be a place for this procedure in the management of long standing suppurative arthritis whether it develops following a missile wound or otherwise. For years, continental surgeons have utilized this procedure extensively even before a joint had been totally destroyed by the septic process. During the recent war, we observed that the French and German surgeons performed many resections of the knee joint following missile wounds, many prophylactically before the development of established sepsis. This procedure has rarely been performed in American and English surgery in the interim between the wars and seldom was it chosen during World War II. A fear of opening up normal bone to infection was one factor mitigating against resection.

I would like to point out again that in Case v, bilateral parapatellar incisions for drainage of the suppurative arthritis were of no avail and the continuing septic process completely destroyed the joint. There was further extension up the thigh.

Had he not previously had an amputation of the other thigh, it seems certain that amputation would have been selected as the means of eradicating this severe septic process as this patient was indeed severely ill. Following resection of the joint which removed the dead infected material and permitted the approximation of healthy bone, the septic process was controlled, the wound healed and an exceedingly favorable result under the circumstances was achieved.

Case vi, while not as dramatic, illustrates the eradication of severe sepsis by resection of a knee joint. It should be pointed out that resection is reserved for those joints which are so destroyed by the septic process or by trauma that future function is hopeless. The degree of shortening which results is determined by the extent of destruction of bone by the infection.

We are certain that there are indications for resection of septic knee joints in civilian practice. These may occur following blood-borne suppurative arthritis, suppurative arthritis resulting from extension from a nearby infected wound or following direct trauma to the joint. The procedure is valuable particularly in joints destroyed by sepsis and complicated by a flexion contracture.

I appreciate Dr. Macey's discussion and particularly his agreement with the principles outlined in my paper. I sincerely hope that there will be a civilian application of the experience in suppurative arthritis here outlined.



# CONSERVATIVE TREATMENT OF SEMILUNAR CARTILAGE INJURIES OF THE KNEE JOINT\*

EVALUATION OF END RESULTS OVER A TEN-YEAR PERIOD

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THE conservative non-operative treatment of semilunar cartilage injuries of the knee joint is by no means a new concept. The prolonged struggle in England between the orthopedic surgeons and the lay "bone setters" bears evidence of the conflict. Sir Robert Jones, Bristow and McMurray have compiled excellent clinical descriptions of injuries to the semilunar cartilages of the knee proved by operative removal of the cartilages. The manipulative measures for reduction of displaced cartilages and the effectiveness of prolonged skin traction in overcoming locking of the knee joint are well known. Numerous writers advise such measures as first treatment, adding as a warning, that success cannot be assured, while Watson-Jones<sup>1</sup> is of the opinion that "non-operative treatment, with its uncertainty, is no less time consuming and incapacitating than operative treatment, which is certain."

Industrial injuries of the knee joint, with the control of the patient offered the surgeon, the hospital facilities offered the patient, and the prompt reporting back of the patient if treatment is inefficient and unsatisfactory, or the condition recurrent, thus preventing the worker from returning to his job in a normal manner, seems to provide an ideal field in which to test the effectiveness of conservative non-operative treatment of semilunar cartilage injuries. That treatment might well be followed in some instances by perfectly satisfactory end results, was strongly indicated by the experiments of Donald King.<sup>2</sup> King showed that in dogs, a torn meniscus can heal by fibrous tissue if the tear communicates with synovial membrane laterally, or if partly torn from its peripheral attachment. He found that in a complete transverse or oblique tear, the intervening space fills with connective tissue, which becomes quite firm in three weeks time, thus suggesting the length of time necessary for complete immobilization of the joint. King also found that a

longitudinal bucket-handle type of lesion entirely within the cartilaginous portion of the meniscus showed no evidence of repair. S. Alwyn-Smith<sup>3</sup> illustrates by photographic examples, healing and partial healing in removed human semilunar cartilages. Many authors, particularly the German and Italian had shown that in humans, after complete excision of the semilunar cartilage, a fibrous reformation approximating in gross appearance the normal, took place.<sup>2</sup> Other observers had produced experimental regeneration of excised semilunar cartilages in animals.

Over a ten-year period, 299 injuries about the knee joint, exclusive of fractures, were encountered. By far, the major portion, eighty-four, were strains and sprains of the joint ligaments, often accompanied by joint effusions, serous or bloody. Serous synovitis following sprain occurred in twenty-one instances, and hemarthrosis was observed in thirty-nine patients. While severe internal lateral ligament injuries occurred in sixteen cases, external lateral ligament injuries were found in only two patients. Cruciate ligament injury was discovered twice. Osteochondromatosis, osteochondritis dissecans and joint mice were each encountered in single instances. It is of interest to note that prepatellar traumatic bursitis was present in forty-five patients, superficial infrapatellar bursitis in eighteen patients and deep subtendinous infrapatellar bursitis in two individuals. One atypical periarticular bursa was found and three patients had a cyst of the external semilunar cartilage. Among these injuries were fifty-six cases diagnosed as having semilunar cartilage injuries after a careful study of the history of the mechanism of the injury and the physical signs presented by the patient.

Of the fifty-six patients, forty-nine were male and seven female. (Table 1.) The internal semilunar cartilage was affected in forty-seven cases and the external meniscus in nine instances.

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The right and left knees were involved equally. Tenderness over the affected cartilage was the most frequent sign of value and was constant in varying degrees of flexion and extension of the knee (96 per cent). Such tenderness was definitely distinguished from that of sprain or

TABLE I  
FIFTY-SIX SEMILUNAR CARTILAGE INJURIES

	No.	Per Cent
Males.....	49	87
Females.....	7	13
Internal semilunar cartilage.....	47	84
External semilunar cartilage.....	9	15

tear of the lateral ligament which is most apt to be near the bony origin of the lateral ligament rather than in the femoral tibial sulcus overlying the cartilage. Again, the tenderness overlying an injured cartilage is not associated with pain on abduction of the extended knee away from the side of the lesion, but is apt to be accompanied by pain on adduction of the knee (particularly if locked in the last few degrees of extension) toward the affected cartilage.

A history of locking of the knee at the onset of injury was viewed with suspicion if not shown at the time of physical examination. An extensive effusion ballooning out the joint may prevent full extension of the knee. After aspirating the joint fluid, serous or bloody, one can quickly detect the presence of true locking. Locking was found on physical examination in forty-two cases or 75 per cent of those diagnosed as having semilunar cartilage injuries. (Table II.) Joint fluid accompanied the cartilage tenderness or locking in thirty-five patients (62 per cent). One instance of accompanying lateral ligament sprain and one apparent anterior cruciate ligament sprain occurred in these semilunar cartilage injuries. One patient suffered a simultaneous longitudinal fracture of the patella. These three patients were treated conservatively with satisfactory end results.

Nine patients gave histories of previous serious knee joint injuries with locking of the joint and disability prior to the injuries for which they came to our attention. In four such cases, it was found necessary to remove the cartilage by operation. Two patients of this group were treated without operation with satisfactory end

results; one patient was treated conservatively, and when last seen a year after his return to work, he still complained of slight discomfort in the knee, but he had no fluid or locking during this time. Two patients with definite semilunar cartilage injuries and a history of previous

TABLE II  
MAJOR PHYSICAL SIGNS

	No.	Per Cent
Joint fluid.....	35	62
Locking of joint.....	42	75
Tenderness over the injured cartilage...	54	96
Right cartilage.....	28	50
Left cartilage.....	28	50

injuries with locking of the knee while working for other employers, were turned down for treatment by insurance carriers, and consequently were lost for treatment and follow-up study.

TREATMENT

In the beginning, our treatment of the patient with semilunar cartilage injury consisted of reduction of the cartilage by manipulative measures, if possible, aspiration of joint fluid if the joint was tense and distended, application of a very heavy voluminous sheet wadding bandage, held by elastic bandaging, and the use of crutches or a cane, advising the patient at the same time to be recumbent as much as possible. In those patients in whom reduction of the slipped meniscus could not be carried out by manipulation were placed in traction in bed. It soon became evident that patients so treated absorbed the joint effusion much quicker, the cartilage was less likely to displace after reduction and their convalescence less prolonged. At first, sheet wadding and elastic bandages were used as the only immobilization after traction reduction. This had to be reapplied constantly. A circular unpadded plaster splint, reaching from the ankle to the upper third of the thigh, was found to be the most satisfactory form of immobilization. Slipping and shifting of the splint was prevented by adhesive strips the length of the leg beneath the cast, turned back and incorporated into the plaster above the malleoli.

The method used in the last seven years is as

follows: In fresh semilunar cartilage injuries, hospitalization with Bucks adhesive traction is instituted at once. Manipulative reduction of displaced cartilage is attempted. If unsuccessful, the reduction is left to constant skin traction. A weight of 8 to 10 pounds is sufficient.

TABLE III

Conservative treatment.....	82%
Operative treatment (10 cases).....	18%
Previous injury with locking of knee.....	9 cases
Previous injury with recurrence—operation..	4 cases
Previous injury with satisfactory conservative treatment.....	2 cases
Previous injury with conservative treatment with slight difficulty.....	1 case
Treatment denied by Ins. Co. because of prior injury.....	2 cases

The adhesive strips run to just below the knee. The malleoli are well padded with soft flannel bandage and felt against pressure of the adhesive strips, and bias cut muslin or flannel is used as a wrapping to maintain contact of skin and adhesive tape. If an effusion is present, such bed rest and traction cause surprisingly prompt disappearance of the effusion, if the meniscus is reduced either by traction or by manipulation. The thirty-seven cases in which traction was used, averaged 7.2 days of traction, ranging from three to thirteen days in individual cases. Aspiration was necessary in five patients, one individual requiring aspiration twice. Recurrence after becoming ambulatory took place in seven patients to be followed by operative removal of the cartilage. In three patients, reduction by manual manipulative means and by traction was unsuccessful. These patients were operated upon. An occasional unreduced cartilage may be manipulated under spinal anesthesia successfully; if reduction fails, immediate operation is performed.

Following reduction of the cartilage and return of full voluntary extension under the influence of traction, provided the fluid has disappeared, the adhesive suspension sling and plaster of paris circular splint is applied. The patient becomes ambulatory and the cast is removed in from twelve to fifteen days. The period of splint immobilization in these patients averaged fifteen days, and in individual cases from eight to thirty-three days.

All patients are instructed in quadriceps exercises from the beginning, and these exercises are enforced by the physician and the nursing staff. When ambulatory in the circular splint,

leg raising and tip-toe standing exercises are encouraged. Upon removal of the splint, an elastic knee bandage is provided, and exercises for regaining movement and maintaining muscular tone and development are prescribed, if, in two weeks, after removal of the splint, progress in

TABLE IV

	Days
Days from injury to initial treatment:	
Average (56).....	10.8
Operated cases (10).....	30.0
Unoperated cases (46).....	6.7
20 days or more—(injury to treatment)....	11 cases
Delayed treatment—6 of 10 operations	

motion and muscular development does not seem satisfactory, exercise, heat and massage are given under the direct supervision of our physiotherapist. Stationary bicycle riding and leg raising with attached weights, as well as previously prescribed exercises, are then carried out.

## RESULTS

The average limbering up period of the non-operated patients after removal of the splint was seventeen days. Naturally, operative cases require a much longer time. In non-operative cases, the period of disability before returning to and remaining at work averaged thirty-seven days. (Table v.) The average days of disability for all cases was sixty-two days, and the average time away from work for the ten operated patients was 152.7 days. Patients were kept under observation until no doubt of the success of treatment remained. The period of observation in the non-operated cases averaged 72.2 days, in the group as a whole, 104 days, and in the ten operated cases, the average days of observation was 223.

Some explanation is necessary in regard to this long disability period of the operated patients. It is of more than casual interest that the average number of days for all patients from date of injury to the initiation of proper treatment was 10.8 days. (Table iv.) In those patients treated conservatively, this period averaged 6.7 days, while in those cases requiring operation, the average number of days from injury to initiation of definite treatment was thirty days, and in individual cases from the day of injury to ninety days after the injury. Of eleven patients reporting for treatment twenty or more days after injury, six required operation. Two who had previously experienced



locking and fluid with prior injuries reported promptly and required operation; six patients reported with recurrence of the meniscus locking after becoming ambulatory under conservative treatment and they were subsequently operated upon.

TABLE V

	Disability
Unoperated cases (46).....	37 days
Total patients—average (56 cases).....	62 days
Operated cases (10).....	152.7 days
	Observation
Unoperated cases (46).....	72 days
Total patients—average (56 cases).....	104 days
Operated cases (10).....	223 days

In one individual, in whom an accurate diagnosis could not be made, constant recurrence of knee joint effusion took place. After 198 days, he was operated upon and an injured cartilage found with a marked synovitis. His period of disability was 300 days. He regained full motion and a stable knee but he continued to have atrophy of thigh and calf.

One patient illustrates an error in surgical judgment. Even though local heat and a hot tender knee was observed prior to operation, the patient had definite evidence of semilunar cartilage injury with locking, fluid and a tender cartilage. Reduction of the locking was accomplished by traction with recurrence of fluid after removal of the splint. After 158 days of observation, the patient had not improved. The knee was still swollen and hot. No focus of infection could be found, the leukocyte found was not elevated, although the sedimentation time was rapid. Operation was carried out, the semilunar cartilage detached in its anterior portion with marked pannus formation from the anterior cruciate beyond the cartilage discovered. On removal of the pannus and meniscus, fragmented, raised articular cartilage of the tibia was found and removed. Convalescence was slow. Local heat, swelling and low grade fever continued for some weeks after operation. A fibrous ankylosis resulted with 20 degrees lack of extension, and only 36 degrees of active flexion, with pain and swelling of the knee on prolonged active use of the leg. This patient returned to another form of work in 330 days and was observed over a 540-day period before being discharged.

Those patients treated successfully by traction, reduction of the meniscus and by splinting, represent 82 per cent, forty-six of the

series, 18 per cent or ten of the series requiring operation. (Table III.) Residual atrophy of the thigh or calf, or impairment of motion of the knee joint at the end of the period of observation of individual cases was surprisingly infrequent (Table VI) and is an objective measure-

TABLE VI

Remaining Measured Atrophy:	
Thigh.....	10 cases
Calf.....	9 cases
Operated cases.....	7 cases
Conservative treatment.....	5 cases
Remaining Limitation of Motion:	
Extension.....	5 cases
Flexion.....	7 cases
Operated cases.....	5 cases
Conservative treatment.....	5 cases

ment of the relative success of the method of therapy. Since the patients in this series were employed by stable, long-standing industrial firms not in war plants, and the patients themselves settled citizens not migrant workers, recurrence of symptoms or exacerbation of difficulty by new injury would have come to our notice.

COMMENT

Regeneration of fibrous structures resembling the semilunar cartilage has been reported in humans after complete removal of the meniscus. Animal experiments have confirmed the fact that such regeneration may recur. Kings experiments show that injuries involving the fibrous portion of the meniscus or transverse or oblique complete tears of the cartilage may be well healed by ingrowth of fibrous tissue, and that true "bucket-handle" fractures of the meniscus involving the cartilaginous portions do not heal. One has no means by which one can diagnose by clinical signs the presence of a "bucket-handle" injury of the cartilage. "Bucket-handle" injuries can be truly discovered only on operative removal of the meniscus.

Long ago Sir Robert Jones emphasized the longitudinal split as the common type of meniscus lesion. A recent writer<sup>4</sup> states that Sir Robert Jones was unable to find such tears of the meniscus in 10 per cent of his operated cases, while Bristow, in careful compilation of injuries, was unable to find such cartilage tears in 30 per cent of the cases he operated upon. Harry Platt<sup>5</sup> found that 33 per cent of patients who were operated upon for previously diagnosed semilunar cartilage injuries showed no

evidence of fracture, and he believed that most cartilages of this group were of the "hypermobile" type. Platt showed that in the cartilages with fracture, 93 per cent had longitudinal tears, and a little more than half of these cases were of the "bucket-handle" type.

It is possible that some few or many cartilage injuries of the longitudinal type might occur near the transition from joint ligament and capsule to the fibrocartilage of the meniscus. If so, one could expect complete healing if the torn surfaces were approximated in the reduction and the joint immobilized. It is not likely that a sufficient wide tear would take place with subsequent healing without immobilization to account for the high percentage of hypermobile cartilages found by Bristow and by Platt. Most of the splits of the anterior and posterior horn run directly into areas of the meniscus which are in direct continuity to the synovial fringes, the infrapatellar fat pad and to the anterior and posterior fibrous horns of the cartilages themselves, all of which would furnish blood supply for the ingrowth of new fibrous tissue for healing, once the cartilage was reduced to a semblance of normal contours and the limb immobilized.

From the tables presented in this study, it is evident that attempts at conservative treatment of semilunar cartilage injuries of the knee joint are definitely worth the effort of the physician. Rapid response to the treatment outlined is the rule. Recurrence or failure of therapy calls for immediate operative removal of the meniscus. The earlier rest, traction and splinting are enforced, the greater are the chances of recovery under conservative treatment, and conversely, the longer the delay in such treatment, the more certain will be the necessity for operation.

#### CONCLUSION

1. In a small carefully studied series of traumatic knee joint lesions, diagnosed as semilunar cartilage injuries, 82 per cent (forty-six patients) were successfully treated by conservative means; 18 per cent (ten patients) were operated upon.
2. The treatment advised is immediate hospitalization, manipulative or constant adhesive traction reduction of the locked joint, aspiration of the joint, if necessary, and immobilization of the injured knee by circular plaster splint.

3. It is shown that the earlier complete rest of injured joint is enforced, the more likely is the success of the conservative treatment, and conversely, the longer the delay in instituting treatment, the more certain will operative intervention be required.

4. Pathologic, anatomic studies of the injured meniscus in patients and experimental work on animals reported by many observers provide a sound logical basis for the success of conservative therapy.

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#### DISCUSSION

GEORGE J. CURRY (Flint, Mich.): Flint is an industrial city with 60,000 factory employees, many of whom are subjected to knee joint trauma. Interannual derangements of the knee joint occur, and over the past ten years a large number have been managed. Satisfactory statistics on follow-up care are impossible because of changing patient personnel. The present plan of management by my associates and myself may be summarized as follows:

1. Such knee joint injuries, if seen fresh, pointing to an internal derangement, presumably diagnosed as a probable disrupted meniscus, are manipulated by gentle manual traction under anesthesia to obtain extension comparable to the degree of the unaffected side. This would indicate a probable restoration of the knee joint continuity and possible replacement of the cartilage. Aspiration is done in cases with marked effusion or hemarthrosis. Immobilization in plaster of paris for several weeks follows. This enables early full weight-bearing. A course of quadriceps exercises is most essential. Following removal of the plaster of paris cast, a second evaluation is made. If there is a recurrence of the disability or positive physical signs, surgical intervention is indicated.

2. All chronic cases of recurrent locking, continuous pain, instability, effusion and so forth, either in combination or alone, are accepted for exploratory arthrotomy and probable excision of the affected

meniscus. We believe that conservative management in this type of case obviously is of little or no value.

3. There is a group of cases presenting minimum, mild, localized pain over the joint with associated tenderness and "clicking" sensations. There is no associated instability, effusion or quadriceps degeneration. This type of case, we believe, indicates a possible partial dislocation or minimal cartilage tear. Quadriceps function and stability are good. These cases are kept under observation and the management is conservative and expectant. If disabling symptoms occur, surgical intervention is strongly considered.

The internal meniscus is damaged more frequently—85 per cent in our cases. The incidence of multiple lesions is relatively high and it is frequently necessary to explore the entire joint. The patient must be thoroughly trained in quadriceps exercises prior to operation.

The larger percentage of all meniscus injuries over the past ten years have required operative management. However, we believe that conservative management of the smaller group is a justifiable plan.

The convalescent period in the operated cases averages much less than five months. Exploratory operation in the cases of questionable diagnosis seems logical.

The statistics presented by Dr. Howard derived from a close follow-up on the conservative management of damaged menisci are very interesting. They serve as a stimulus to some of us whose experience is the reverse.

THOMAS B. QUIGLEY (Boston, Mass.): The experience of the Harvard Athletic Association is in agreement with the experience of Dr. Howard, because since 1932, under Dr. Thorndike's leadership, a conservative policy has been followed with regard to knee injuries.

We agree with the speaker and the previous discussor in principle, but we differ somewhat in the details of the therapy. This problem of knee injuries can be considered, at least from certain points of view, as a local problem; what might be right and proper treatment for a shipfitter is not always necessarily applicable to an undergraduate athlete.

Our program has been two-fold: (1) prevention of injury and (2) therapy. The preventive aspects have been discussed before this Association in the past by Dr. Thorndike and very briefly consist of a survey of all old knee joint injuries in athletes who indulge in contact sports, and preventive taping.

As to therapy, traction is out of the question for these undergraduate athletes. Modern college life is a chain reaction it seems, and if one loses even a week, one is likely not to graduate. Therefore, our patients are almost always ambulatory, the keynote of treatment consisting of compression dress-

ings, careful physical therapy, which is principally active exercise and rest of the joint on crutches. The crutches do not disable the undergraduate student from doing his job, which is to study. Actually, they make him study more because it is too much trouble to go to the movies on crutches.

W. McGAW (Cleveland, Ohio): This paper and the discussions have interested me very much. While in the Southwest Pacific during the war we had a large number of knee cases at one time, some acute and some recurrent. We became interested in the use of pneumograms in helping us in the accurate diagnosis and in the treatment.

While we were overseas, we saw some 500 cases that were studied with pneumography. Of this group, 180, or approximately 35 per cent, were operated upon. The rest of them were treated conservatively. A few of these however, were sent back to the States if we believed we could not rehabilitate them overseas.

I think we all agree that in knee injuries, the treatment rests so much on an accurate diagnosis. We all realize that the contusions will heal conservatively, sprains will heal, torn ligaments will heal if they are protected, tears in the synovia will heal. The difficulty arises in cases that do not heal so readily and adequately.

We have believed, and agree perfectly with Dr. Howard and the discussors, that a meniscus injury will heal if it occurs near the coronary ligament or its attachment to the capsule. However, we also believe that if there is a dislocation, multiple tearing and shredding of the menisci, or a history of many previous injuries, these cases should be treated the sooner the better by surgery. We have believed that with the use of pneumograms we could diagnose many of these cases early when first seen. We know that we could diagnose single and bilateral tears, and dislocations; we could tell in many cases whether the tear was near the periphery. I make a plea for early accurate diagnoses of all injuries of the knee. The treatment should be planned on a specific diagnosis. It is believed the conservative treatment is the proper treatment in about 60 per cent of all knee injuries.

JOSEPH M. MEHERIN (San Francisco, Calif.): I think for a number of years many of us have been very hesitant to operate on the older age group with injuries to the semilunar cartilages. I think Dr. Howard's paper brings out something that we perhaps have not clearly realized. Initial injuries in this older group have responded very well to conservative treatment.

The time relation between the initial injury and the institution of treatment is extremely important. Dr. Howard has given me the privilege of reading his paper and I would say that he was too honest. The period of 152 days is, as is always in honest statistics, a little too high. Very often, in the

other type of statistics, the periods of disability are much too low. In reviewing these cases, one sees that there was one case with a disability of 300 days and another with 332 days. If those are included, you can understand a period of average disability of 152 days much more readily.

I would like to bring out again something that has been stressed time after time but that I think we neglect, namely, in puzzling cases we can very often get useful facts by examining the patient's knee while the patient is standing.

I would like to ask Dr. McGaw if he would take one minute or two to tell us a little more about days of disability, how many of those patients were sent back to the States.

PRESIDENT CAROTHERS: I am sorry, Dr. Meherin, but he may not discuss twice.

DR. MEHERIN: I see. Well, those are answers that are very difficult to find out. I have tried to find out a good deal about them while I was in the service and, of course, they are not actually available.

AUGUSTUS THORNDIKE (Boston, Mass.): Age has a great deal to do with the reparative powers of the meniscus. Dr. Quigley was speaking of a young and virile group. Dr. McGaw did likewise. But when you talk about the industrial case you are talking of an age group that is in relatively poor physical condition as compared to the soldier or the athlete.

I find that much time is lost, as I look around among civilians I see treated, in the fact that doctors and patients allow effusions to accumulate. We found that the shortening of the time of convalescence was due to controlling the effusion. We rarely see an effusion in a knee today. We apply cold, ice water, for a period of one-half hour, and a sponge-rubber compression on sheet wadding after that, and it is perfectly extraordinary how well it controls the effusion.

It is rarely that we have an arthrotomy, and as Dr. Quigley pointed out, we check up on all entering freshmen to inquire if they had an injury or sprain before they enter college. It is our experience that meniscus injuries are rare with the first sprain; that it is the subsequent sprain to a weakened ligament that damages the cartilage or causes the cartilage to be damaged.

We do not immobilize in a cast and we apply physical therapy as soon as we are sure that the possibility of a hemorrhage being started by massage is over, on the third day, and in the weight-bearing joint; of course, we keep them on crutches for that period. But we have had great success with an average time of sixteen days in our knees before they go back to playing football.

The industrial cases pointed out by Dr. Howard were ten days before they got to him. That is ten strikes on him already. It is too bad. It delays the

period of recovery a great deal. If our industrial injuries could be put back to work, there would be a great saving to all if we could do it as fast as we can with the athlete. I enter a plea for prompt, early treatment of these cases and control of effusion, when possible.

NELSON J. HOWARD (closing): I want to thank Dr. Curry not only for his kindness in discussing the paper but also for his kindness and his charity at the same time in his expressed opinions. I rather have the feeling that he is not quite so sure that the conservative treatment will give the results that I have shown to you today.

I do believe, first of all, that the immediate treatment of the injured individual has a great deal to do with the success of the treatment. There are always going to be those "bucket-handle" fractures which cannot be reduced or those fractures of the cartilage which are in the purely fibrocartilaginous portion of the meniscus, which will not heal.

I want to emphasize that we have the opinion that if the conservative treatment is not promptly adequate in your clinical judgment, that patient should be operated on without further waste of time. This is not a plea against operation, but it is a plea for operation in only those cases that need it.

Dr. Quigley was very kind in bringing up the statistics from Harvard among the amateur athletes. I think that Harvard is particularly fortunate in this country in having a carefully controlled, medically controlled, group of athletes. That is not by any means the rule of the country and I believe that the amateur at least is like a race horse: He has a short life of intense activity and a long life; oftentimes, of crippling disability or discomfort from it. Many of the men in the audience can remember that from their college days. I have seen a man with a dislocated shoulder taken out of a football game, his shoulder incompletely reduced—you could see that it was incompletely reduced from the stand. He would hold it as if he had a luxatio erecta. That patient would be sent right back into the football game to have the shoulder redislocated on the next play.

I have not had any experience with pneumograms of the knee joint. A good many years ago, when I was first considering the problem of using pneumograms on the knee joint, I happened to run into five successive references within two weeks' time on fatalities from air embolism, so that my enthusiasm was discouraged and I did not begin the use of them. I am glad to know that Dr. McGaw has had success with them and I would like to know more about it from him later.

Dr. Meherin asked about the age incidence of these patients. Dr. Meherin and I have been associated with each other in San Francisco for a time, and Dr. Meherin himself took care of a few of these patients that I have shown you. When he first

asked me this question, I went back and tabulated the age groups by decades, and I found that by far, the majority of the injured individuals were between thirty and forty and forty and fifty years of age. There were two people in their eighth decade still working, receiving these injuries as industrial injuries, over seventy years of age. One of them responded beautifully to conservative treatment; the other had to be operated on and his work disability was only sixty days before going back to full work.

Dr. Meherin mentioned the disparity between the total period of disability in operative cases and the short period of disability for the conservatively treated cases. That might leave you with a misapprehension. There were two cases of prolonged disability which were operated upon, which gave rise to this poor statistical result. One was an individual who had a chronic and recurring effusion of the knee joint. It was extremely difficult to diagnose the true lesion. He was an inebriate bartender who fell down a flight of stairs. He came to us late with an effusion. It was difficult to determine whether he had a semilunar cartilage injury. At no time did he have a history of locking or, on physical examination, locking of the knee joint.

Finally, after 180 days of constant recurring effusion, in spite of bed rest, traction and aspiration, his knee joint was explored. A torn semilunar cartilage was found—without a history of locking, without physical signs of locking—and his total disability was 300 days.

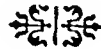
The second one with prolonged disability was a mistake in surgical judgment. That man came to us

rather late with a fresh injury, but rather late after the injury. He had a hot joint. He had definite tenderness and locking. He had no fever, he had no leukocytosis, but he had, very definitely, a markedly elevated sedimentation rate. The joint locking responded to adhesive traction. The effusion disappeared within thirteen days—rather prolonged. He was placed in a working splint and was allowed to walk for three weeks. On removal of the splint, locking and recurrence of a slipped cartilage took place, and effusion came on again, so he was operated upon, in spite of the fact that he had a warm joint, and at operation, a pannus was found running from the cruciate ligament to a split in the anterior horn of the semilunar cartilage. When the pannus was removed, it was seen that the joint cartilage beneath the semilunar cartilage had been fragmented and raised 1 or 2 mm.

Another mistake was made when this elevated joint cartilage was excised. This patient has a rather stormy postoperative course but a prolonged one; he had low-grade fever, marked effusion of his joint, he ended up with a stiff, ankylosed and painful joint, with only 30 degrees of motion. He had to change his occupation, and he did not go back to work for 330 days and was kept under observation for some 500 days.

With those two exceptions, all of the operated cases, actual fractures of the semilunar cartilage that were found, had a period of disability before going back to heavy work ranging from only sixty to ninety days.

I am sorry that I do not have time to discuss the other remarks.



# MULTIPLE MUSCLE SUBSTITUTION FOR CORRECTION OF FACIAL PARALYSIS

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**F**ACIAL paralysis presents not only a disabling and disfiguring deformity, but a most difficult problem from the standpoint of satisfactory correction. One should not be content merely to give support to the affected muscles; it is also necessary to restore as much motion as possible to the entire paralyzed side of the face. This may tax to the limit the ability of the most highly skilled surgeon.

In paralysis incident to simple severance of the facial nerve, regeneration may follow suture of the two ends. In the event the ends of the nerve have probably been bruised, permanent suture is best delayed until the eighteenth to the twenty-first day following injury, since one can then determine the exact extent of the damage to the nerve beyond the point of severance. In the presence of a small gap in the nerve, a free graft may often be utilized for repair. A defect in that part which lies within the facial bony canal lends itself well to the nerve graft procedure described by Bunnell in 1927. If neither of these methods is feasible, a satisfactory result may occasionally be obtained by an anastomosis of the distal end of the facial nerve to one of the other cranial nerves, usually the eleventh.

For extensive injury of the nerve or permanent paralysis, either fascial strips or muscle pedicle grafts may be utilized. By far the most popular technic has been the use of fascial strips attached to the temporalis fascia or muscle, or both, the strips being carried down to give support to the most noticeably sagging areas of the face. There are two reasons for the popularity of this procedure: the technic is simple and the improvement is immediate. No motion is obtained, however, or at least only a negligible amount. Neal Owens has utilized the masseter muscle in preference to the temporalis, attaching the fascial strips to the lips and corner of the mouth and looping them through the body of the masseter muscle. He has found that this not only provides support, but the results are definitely better with respect

to motion about the corner of the mouth than following the use of the temporalis muscle.

Muscle transplantation provides support equal to that of fascial strips and, in addition, permits voluntary motion. In some cases, moreover, fascial strips tend to relax, with a consequent return of the sagging of the muscles, whereas following the transplantation of muscles, the tone improves as reeducation of the transplants is continued.

The principle of muscle substitution seems to have been first employed by Lexer in 1867, who transplanted a pedicle of the masseter muscle to the corner of the mouth, to give motion in this region of the face. A number of other surgeons have since transplanted the masseter muscle by one technic or another for the same purpose. Gillies and Sheehan have each employed the temporalis alone for restoring motion to the entire side of the face. The muscle is detached at its origin above, divided into strips and brought down; one strip is attached in the upper eyelid, one in the lower lid, one in the supra-orbital region and one or more around the angle of the mouth. When the temporalis muscle is transplanted to the region of the mouth, however, its pull is largely upward and only slightly backward. This muscle is most suitable for restoring motion and giving support to the eyelids, providing, as it does, a slightly upward pull.

In paralysis of the facial nerve, there is a loss of function of eleven major and nine minor muscles of expression. One cannot, therefore, expect one muscle to carry out the work of the entire group. Obviously, the larger the number of different muscles which can be brought into play, the better the function one will be able to restore to the paralyzed area. By substituting muscles from different locations, muscle pull in various directions may be provided, thus insuring a more nearly normal direction of motion.

The masseter muscle, because of its location, is most suitable for reanimating the corner of the mouth and the lower part of the paralyzed

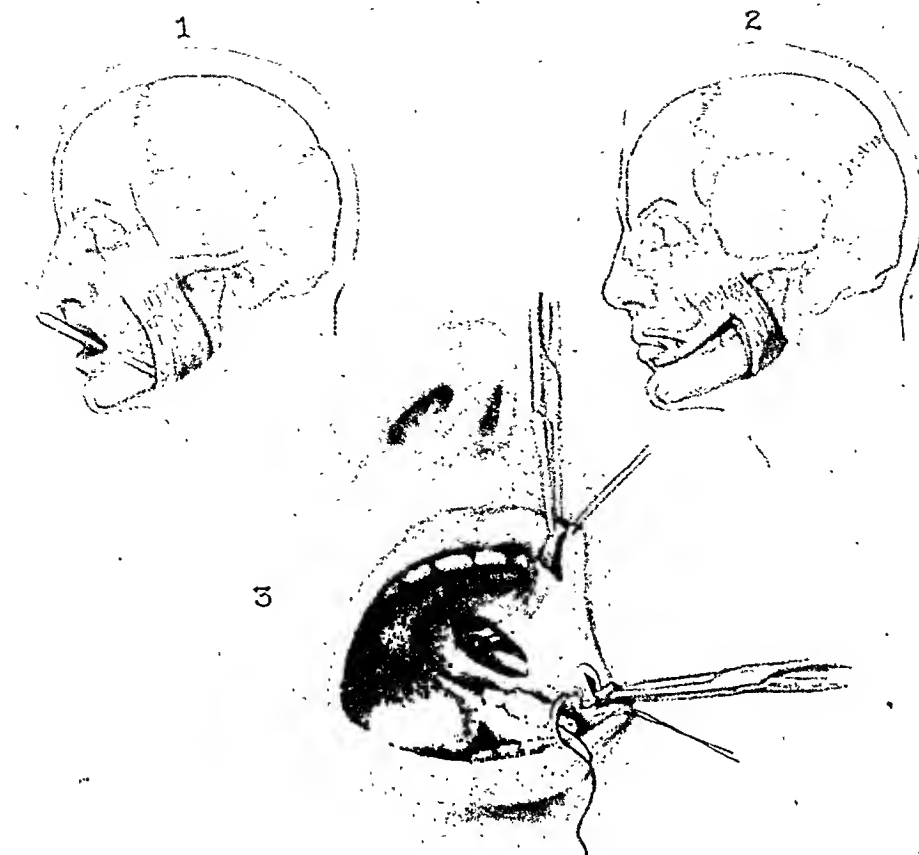


FIG. 1. Transplantation of the masseter muscle to the region about the angle of the mouth. (1) Freeing the masseter muscle from its insertion along the lower border of the mandible through an incision in the buccal mucosa. (2) The masseter muscle flap divided at its distal end and swung anteriorly to the region about the mouth. (3) The muscle flap being threaded through the formed tunnel beneath the mucous membrane of the mouth into the body of the orbicularis oris muscle of the upper and lower lip. The ends of the flaps are sutured as near the midline of the lips as possible. A third suture is placed at the lateral border of the orbicularis oris muscle where it conjoins with the risorius to bring out the nasolabial expression line. (See footnote p. 664)

face. By transplanting the end of the insertion of the muscle at the lower border of the mandible, one is less likely to disturb the nerve supply, the pull is in the desired direction, being slightly upward and backward, function is thus more active and the effect is more natural than if the temporalis muscle were utilized.

The operation is best performed under local anesthesia, in that it is desirable to have the patient's assistance in contracting the muscle from time to time during the operation. Unless the masseter muscle is unusually small or is attached posteriorly on the body of the mandible, the intra-oral approach is used. By having the patient clinch the teeth, the body of the muscle is brought forward against the buccal mucosa. On incising the mucosa along the anterior margin of the muscle, one

immediately encounters the muscle and may readily deliver it through the incision. (Fig. 1.) If the muscle is attached more posteriorly on the mandible, an extra-oral approach along the lower border of the mandible is preferable.

The pedicle is dissected up from the lower margin of the mandible and the fibers are separated longitudinally by gentle finger dissection. The muscle should be divided only for a sufficient distance to form a flap of proper length, as the higher the dissection is carried, the greater the danger of impairing the nerve supply. A small incision is next made in the mucous membrane of both the upper and lower lips, just lateral to the midline at or near the vermillion border. Through each of these incisions a tunnel is formed through the body of the orbicularis oris muscle, the tunnels meeting at the corner of the mouth. The



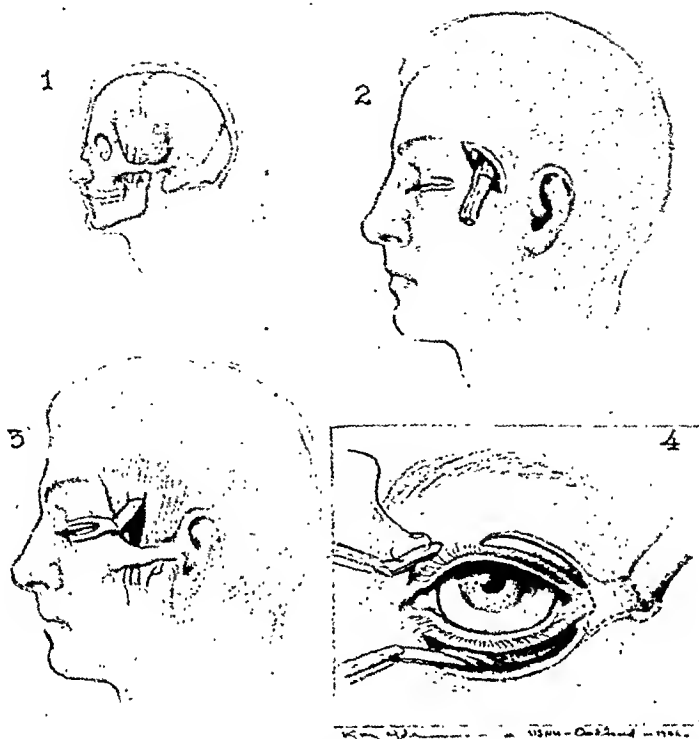


FIG. 2. Transplantation of a flap of the temporalis muscle to the eyelids. (1) The location and amount of temporalis muscle used to form a flap; (2) the freed temporalis muscle flap with overlying fascia intact; (3) the overlying fascia reflected down from the body of the muscle to give needed length to reach the inner canthal region and divided to give a strip for both the upper and lower eyelids; (4) the flaps threaded through the eyelids and the ends sutured in the inner canthal region.

tunnel is then continued backward from this point to the masseter region.

The distal end of the pedicle is now split in half for  $\frac{1}{2}$  to  $\frac{3}{4}$  inch, and the upper and lower halves are delivered through the tunnels of the upper and lower lips, respectively, and attached to the muscle. A third suture is placed in the fork of the pedicle, which is just lateral to the corner of the mouth; this aids in forming the nasolabial expression line when the patient contracts the muscle.

Within two months after the operation, the patient is able, by clenching the teeth, to develop fairly satisfactory control of the pedicle, with motion in the corner of the mouth and surrounding region. Further improvement may be expected for an indefinite period, as long as the patient persists in daily exercise of the muscle.

The temporalis muscle is utilized in a similar manner to restore support and function to the paralyzed upper and lower eyelids. Again, the end of the insertion of the muscle is trans-

planted. A vertical incision  $1\frac{1}{2}$  inches in length is made inside the hairline and just above the zygomatic arch, usually anterior to the temporal artery. (Fig. 2.) The muscle flap, which should be about  $\frac{1}{2}$  inch wide, is dissected up from the anterior portion of the coronoid process of the mandible. To sever the attachment from the coronoid process, long slender scissors with an acute angulation at the ends of the blades are used. The overlying fascia of the temporalis muscle is left attached to the flap and, in order to lengthen the flap sufficiently to reach the inner canthal region, the fascia is reflected downward. Here, also, in forming the pedicle, the fibers are separated longitudinally with gentle blunt dissection to interfere as little as possible with the nerve supply.

A tunnel is created through the subcutaneous tissues from the temporal incision to the outer canthal region, thence through both eyelids to the inner canthal region. The distal end of the flap is split for a distance of 1 to  $1\frac{1}{2}$  inches,

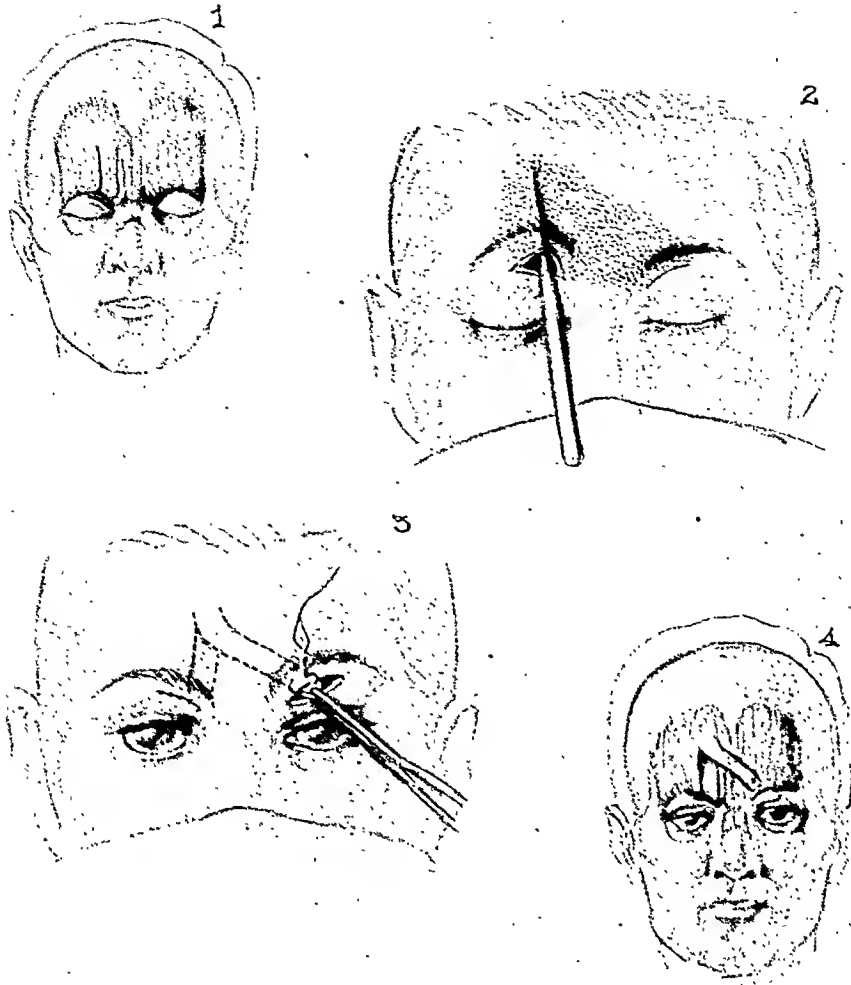


FIG. 3. The transplantation of the frontalis flap to the opposite eyebrow region. (1) and (2) show two small incisions at the inner border of the eyebrow just below the hairline and the area of skin of the central portion of the forehead undermined at the donor site of the frontalis flap. (3) and (4) show the flap being swung over to its new location and the point of fixation of the distal end.

and one-half is threaded through each of these tunnels, brought together and attached to the inner canthal ligamentous tissue. A malleable dissecting probe is useful in delivering the flap through the tunnel, a thread being tied around the ends of the flap and passed through the eye of the probe. One should be careful with respect to the tension on the flap; the tension should be sufficient to permit closure of the lid on relaxation of the levator, yet not enough to prevent raising of the lid on contracture of this muscle. The tension may be tested by having the patient open and close the lids before the transplant is permanently sutured in place.

The immediate effect of this procedure is dramatic, in that the patient is able to open and close the lids at will as soon as the muscle flap is attached to the inner canthal ligament.

It is my impression that this is not a result of the contracture of the muscle pedicle; rather, the tension of the flaps automatically draws the lids together upon relaxation of the levator palpebral and orbicularis muscles. The ability to open and close the lids by contracture of the transplanted muscle is not acquired until two or three months later.

Some patients with facial paralysis have extremely active muscles of the brow and forehead, the brows being constantly raised and lowered. An active forehead on one side, in contrast to the blank immobility and drooping lid and brow of the paralyzed side, presents a conspicuous disfigurement. By transferring a muscle flap of the active frontalis to the muscle bed of the paralyzed eyebrow, attaching it just beyond the midline of the fore-



FIG. 4. A, Case 1. Preoperative picture showing patient attempting to close eyes, muscles of expression relaxed; B, patient smiling showing asymmetry of the face.

head, one cannot only support and elevate the drooping brow, but can also restore some degree of upward motion in this area.

The frontalis muscle is transplanted through two incisions  $\frac{1}{2}$  inch in length at the inner border of each eyebrow, just below the hairline. (Fig. 3.) Through these incisions, the skin overlying the middle third of the forehead is completely undermined. An incision is made beneath the skin down to the periosteum in the midline of the forehead from the hairline to the glabella region. From this point, the medial  $\frac{1}{4}$  or  $\frac{1}{2}$  inch of the frontalis muscle is severed at its lowest attachment and divided high enough to permit the distal end to be shifted across the midline into the opposite eyebrow region. In pedunculating the muscle, the fibers are separated vertically by blunt dissection. The pedicle is sutured into the body of the orbicularis oculi supercilia muscle with No. 0000 chromic catgut. Although the muscle pull is more or less obliquely upward near the midline of the forehead rather than vertical, the result is a distinct improvement over the previous deformity.

Approximately three months is required for restoration of function to this transplant, in contrast to the two months required for the same purpose following transplantation of the temporalis and masseter muscles to the eyelids

and mouth. The rate of improvement and the end results are in direct proportion to the amount of exercise given the involved muscles.

Following all these procedures, an elastic pressure bandage is applied, to be worn for one week as a precaution against postoperative hemorrhage and excessive swelling of the tissues. Motion should not be attempted for eighteen to twenty-one days after operation. The patient is then instructed in the necessary movements and is encouraged to carry out the exercises faithfully every day, preferably before a mirror. Electric stimulation for a few minutes daily is useful as an aid in reeducation of the muscles.

In the transplantation of muscle flaps, several facts should be borne in mind, otherwise the operation may be a failure. First, the flaps should be of sufficient size to insure the necessary strength and support to the paralyzed region. Second, the tension on the flaps should be ample to insure support and motion; on the other hand, undue stretching may lead to ischemia of the flaps. Likewise, too much angulation of the pedicle might interfere with its circulation. Third, we cannot too strongly emphasize the importance of care in separating the muscle fibers to form the flap in order not to disturb the nerve supply any more than necessary.



FIG. 5. Case 1. Six months postoperative pictures. A, showing patient with eye almost closed and face bilaterally symmetrical in relaxed position; B, patient with eyes open, smiling slightly, showing the two sides of the face practically bilaterally symmetrical.

The results of these procedures, though far from perfect, are believed superior to those obtained by the usual supportive operations, either by fascial strips or the use of only one muscle. In each of the three transplants, the point of insertion of the muscle, rather than the point or origin, is pedunculated. Physiologically and mechanically, this insures the least interference with its circulation, nerve supply and direction of pull. Function improves as the patient re-educates the muscle and its tone increases. By continued efforts along this line, I am confident that we can give these patients consistently better results, bearing in mind the fact that muscle transplantation offers most to those with a definitely permanent paralysis.

#### CASE REPORTS

CASE 1. B. F. S., female, aged twenty-one years, was observed in the Plastic Surgery Department of the U. S. Naval Hospital, Oakland, California, having been referred by the Neurosurgical Department following removal of a neurofibroma from the left eighth nerve. The tumor had been located beside the brain stem and had extended from the left temporal notch to the region of the medulla. The seventh nerve throughout this region had been sacrificed in its removal. The patient's convalescence was uneventful, though the left acoustic and facial nerves were permanently para-

lyzed. She wore a plastic support hooked into the corner of the mouth and attached around the left ear. (Figs. 4A and B.)

One month after removal of the neurofibroma, the first stage of the repair was carried out. A muscle flap about  $\frac{3}{8}$  inch in diameter and  $2\frac{1}{2}$  inches in length was obtained from the anterior third of the temporalis muscle by dissection from its insertion at the head of the coronoid process of the mandible. A tunnel was made beneath the skin over the malar bone and across the upper and lower eyelids, and the flap was passed through the tunnel to the outer corner of the eye. At this point, the distal 1 inch of the pedicle was split in half, and each end was sutured into the orbicularis oculi of the upper and lower lids near the mid-portion.

Three weeks following operation, it was observed that the patient slept with the eyelids closed. Between the fifth and sixth week, she was able partially to control the lids by clenching the teeth. Function gradually increased, and by the end of three months she was able to close the lids completely. This function was better when the patient was not fatigued. Although control of the lids was not entirely restored, the result was a material improvement. It is believed the outcome would have been more successful had the muscle flap been long enough to reach the inner canthal region. Function might still be improved by an elongation of the fascia to the inner canthus or by a simple fascial implant to support the lower lid.

Three weeks after the foregoing procedure, an intraoral incision was made along the anterior

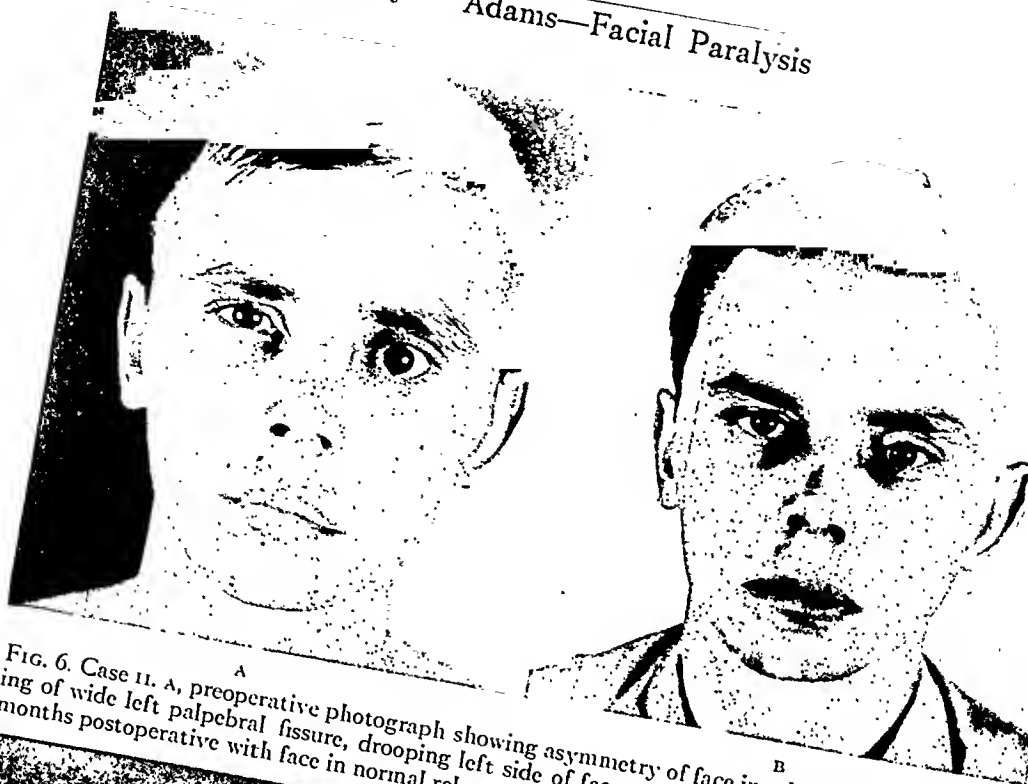


FIG. 6. Case II. A, preoperative photograph showing asymmetry of face in relaxed position. Drooping of wide left palpebral fissure, drooping left side of face and pulling of mouth to right. B, six months postoperative with face in normal relaxed position.



FIG. 7. Case II. A, preoperative picture showing marked asymmetry of facial muscles of expression with patient trying desperately to close left eye; B, six months postoperative picture showing patient able to completely close left eye and retract left corner of mouth. Nasolabial fold definitely formed.

border of the masseter muscle, and a pedicle graft was dissected from its attachment at the lower border of the mandible. The distal end of the pedicle was split and transplanted into the upper and lower lips, according to the technic described. A light pressure bandage was applied and maintained over the area for one week. The patient was

able to contract the corner of the mouth after five weeks.

To support and restore motion to the eyebrow region, a flap of the frontalis muscle on the right side,  $1\frac{1}{2}$  inch in diameter, was detached from its insertion, swung across to the paralyzed left side and attached into the body of the orbicularis oculi

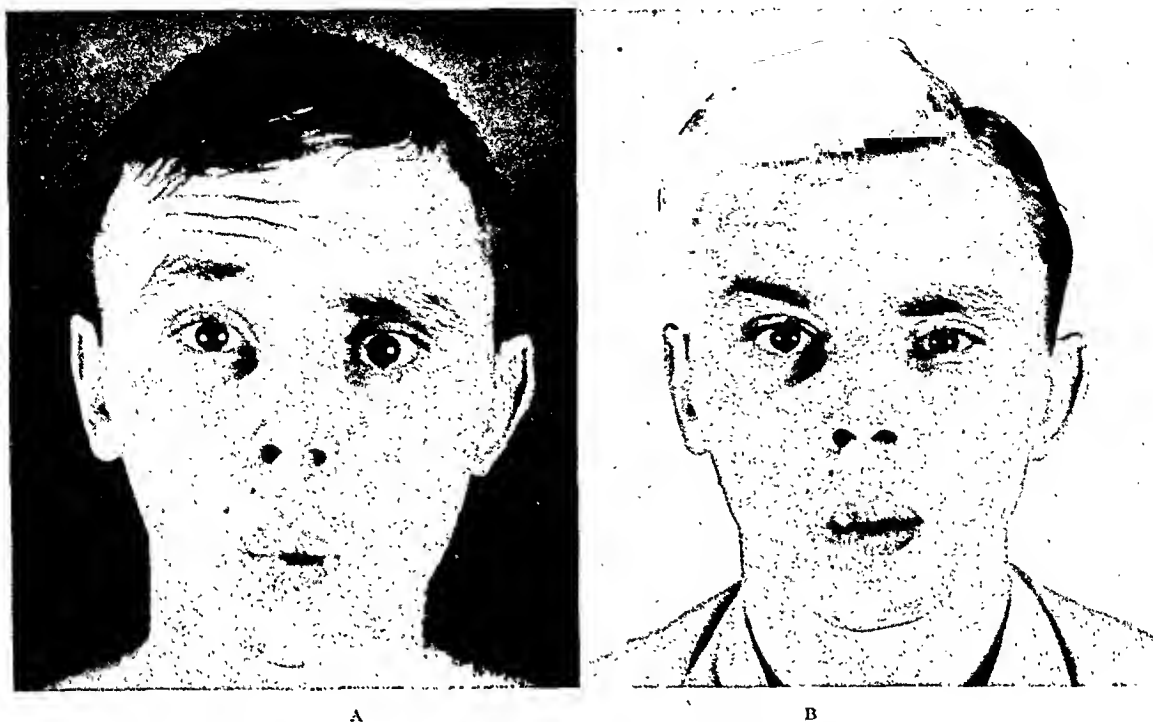


FIG. 8. Case 11. A, preoperative photographs showing marked asymmetry with the patient attempting to whistle; B, six months postoperative showing improvement with patient whistling. Marked improvement in asymmetry of entire face.

supercilii muscle and the lower portion of the frontalis. The first movement of the medial portion of the left eyebrow was observed two months later.

Unquestionably, this was a case of complete, permanent paralysis, without any possibility of a return of function except by surgical treatment. Circumstances prevented the patient from receiving more than one electrical treatment each week for the first two months. The function obtained by the three muscle transplantations was not entirely satisfactory (Figs. 5A and B), yet the improvement obtained must be accredited to the operations. At her last observation, the paralysis was not obvious and, when relaxed, the two sides of the face were almost symmetrical.

**CASE 11.** J. E. S., Corporal, U. S. M. C. R., aged twenty-two years, had received a through-and-through gunshot wound of the head during active duty. The bullet had entered just below the left eye, ranged through the left side of the face, through the inferior portion of the malar bone and the facial canal, and emerged through the left mastoid region. The wound had been débrided and drained in a field hospital. Roentgenograms had revealed a comminuted fracture of the left malar bone, the lateral wall of the left maxilla, the neck of the condyle of the mandible and the left mastoid process. There was no previous history of paralysis or sensory disturbance.

The patient was admitted to the Neurological Service of the U. S. Naval Hospital at Oakland, California, six weeks following the injury. He had a healed scar at the entrance of the bullet below the left eye, and another behind the left ear. Neuro-

logic examination revealed a complete left facial paralysis. (Figs. 6A, 7A and 8A.) The left pupil was dilated and fixed, and a massive white area was present in the lower outer quarter of the retina. Below the bullet wound of the cheek, sensation was lost over an area approximately 3 inches in diameter, and there was some weakness in the muscles of mastication on the left. Hearing in the left ear was totally lost. No other signs of nerve injury were elicited. The right side of the face was normal.

For a period of four months, the patient wore a plastic hook in the corner of the mouth and attached around the left ear, to support the left side of the mouth. Repeated neurologic examinations revealed no evidence of regeneration of the facial nerve during this period. The paralysis was therefore regarded as permanent and the patient was transferred to the Plastic Surgery Department for treatment.

Under local anesthesia, a flap of the temporalis muscle, about  $\frac{1}{2}$  inch in diameter and 3 inches in length, was dissected from the head of the coronoid process through a vertical incision. The fascia of the muscle flap was reflected downward and split into two parts, one for each eyelid. Profiting by our experience in the previous case, wherein we had depended entirely upon the temporalis muscle flap, which reached only to the mid-portion of the eyelid and thus failed to support the lower lid sufficiently to permit full closure of the lids, the pedicle in the present case was made of proper length to reach the inner canthal region, in the hope of providing the necessary support. A tunnel was made beneath the skin over the malar bone and

across the upper and lower lids, the two halves of the pedicle were delivered through these tunnels and the distal ends were sutured into the inner canthal region.

Through an intra-oral incision along the anterior border of the masseter muscle, the anterior half of the muscle was pedunculated from its attachment at the lower border of the mandible. This pedicle was made at least one-third larger than that used in the first case in the belief that the results might thus be improved. The distal end of the pedicle was split and the flap was threaded through a tunnel constructed beneath the buccal mucosa to the corner of the mouth. The two ends were then passed through the body of the orbicularis oris, one through the lower lip, the other through the upper lip, and sutured to the muscle near the midline. To accentuate the nasolabial fold, the flap was sutured to the outer border of the orbicularis oris at its junction with the risorius muscle. A light pressure bandage was applied to the left half of the face.

To prevent swelling and intervention of the mucous membrane between the upper and lower teeth, a thin mold of dental wax was inserted between the teeth and soft tissue of the cheek and left in place for several days. The pressure bandage was removed at the end of one week.

The most noticeable disfigurement at this time was the paralysis of the left half of the forehead and eyebrow region. To correct this condition, a flap of the right frontalis muscle,  $\frac{1}{2}$  inch wide, was detached from its insertion, swung across to the paralyzed side, and fixed to the body of the orbicularis oculi superciliar muscle and the lower portion of the paralyzed frontalis muscle.

Although the patient had support of the lower lid immediately following operation and the lids remained closed when he slept, he was cautioned against exerting the muscles of mastication for two weeks. After this period, he was instructed to begin reeducation of these muscles by clenching his teeth. By the end of the third week, he could partially close the lids on tightly clenching the teeth. The function of the lids continued to improve, and after the fifth week he was able to close the eyelids at will.

The patient had no controlled contracture about the corner of the mouth for a period of four weeks. In order to re-educate the muscle, he practiced at length before a mirror, and from the third week postoperatively, received daily electrical stimulation of the muscle. The first motion about the corner of the mouth was observed at the end of the fourth week. Strangely, he could move the corner of the mouth only by clenching his teeth and moving his right ear at the same time. One week later, he was able to contract the corner of the mouth without moving his ear, and thereafter contracture of this area progressively improved.

Nine weeks elapsed before any motion was apparent in the eyebrow region, and then only a slight twitching of the inner half of the left brow obliquely upward and medially was present. Four weeks later, the right eyebrow became extremely arched, producing a marked contrast in the two halves of the forehead. With a No. 11 Bard Parker knife blade, a small incision was made in the skin of the forehead  $\frac{1}{2}$  inch above the middle third of the right eyebrow, the greater portion of the frontalis muscle was incised horizontally down to the periosteum and a pressure bandage was applied. This decreased to some extent the overcontracture of the frontalis muscle. The contracture of the frontalis pedicle on the left was not pronounced at the patient's last observation, six months following operation, though the eyebrows were symmetrical when at rest and motion was still improving.

After the fourth month, motion of the eyelids and about the corner of the mouth improved only slightly. At six months, the patient could close the eyelids and contract the corner of the mouth only by clenching the teeth. (Figs. 6B, 7B and 8B.) With his mouth open, he could retract the left side of his face on holding the muscles of mastication tense.

Electrical stimulation to the facial nerve had no apparent effect until seven months following operation. At that time, a little movement of the muscles of expression of the lower half of the face, indicating a slight regeneration of the nerve to this group of muscles, was observed on stimulation of the nerve just anterior to the mastoid process. Whether regeneration of the nerve will continue is difficult to predict. In any event, correction of the paralysis was satisfactory by the end of the second month following operation.

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#### DISCUSSION

DONALD M. GLOVER (Cleveland, Ohio): I can only express admiration for this beautiful contribution to repair of the very disfiguring effects of facial paralysis. I cannot discuss it because I have not done the operation in this way. Frankly, I have always been a bit skeptical about the future of muscle slip transplants from limited experimental observation, but the results shown are convincing and the method deserves wider use than it has had.



I would like to ask a couple of questions of the essayist, if I may: First, about the future of muscle slips, whether or not he has had any opportunity to observe them over long periods of time to determine how much fibrosis takes place in the muscle slip and how much function remains permanently? In this particular case, with the beautiful result which is unquestioned, I thought that at the outset the patient had a little facial muscle function before the operation and I was wondering if that was a complete nerve loss or if there was any function at all in the nerve or any tendency to regenerate on the part of the facial nerve.

It has been observed, I think, by almost everyone who has done the fascial transplant operation for facial paralysis over a period of years, that the patients so treated, develop apparent movement of a slight degree in the side which is paralyzed. This movement appears to be contributed by the tension on the unaffected muscles of the good side. These patients may thus have a little sham movement on the paralyzed side which gives the impression of function which is not actually there.

EDWARD A. KITLOWSKI (Baltimore, Md.): This work by Dr. Adams again brings up a question which has puzzled us through the years: What function remains after a period of years in slips of muscle and how much fibrosis takes place?

As Dr. Glover mentioned, we have evaluated paralysis in many cases in this way: In a great many of the cases there is some regeneration of the nerve. Now, the flaccidity of the face stays because the muscles on the good side have overstretched the muscles on the weakened side, so that even though some nerve supply comes back, that muscle is overstretched so that it cannot function in opposition directly to the muscles on the other side.

With simple fascia transplants, you can help that muscle to such an extent that I will even go further than Dr. Glover and say that in some of these cases, we believed definitely that there was muscle function after a period of years. That muscle has had a chance to contract some, and will then exhibit its activity in conjunction with that contraction.

In cases of Bell's palsy, we have always thought it very important that early, very early, a hook attached to a head strap be put in the corner of the mouth to keep traction on the affected side. Quite frequently, if that is done conscientiously, the muscle will not be damaged during the period when that nerve is coming back and what looks like a very sad result will ultimately show a very satisfactory face.

I managed to get some of the statistics from Dr. Lexer's clinic, where they had done sixteen of these muscle transplants of the face. After experience with sixteen of them over a period of about six or eight years, Dr. Lexer decided that they were not

worth the doing. Apparently there was so much fibrosis that it simply acted as straps, and fascia transplants would be just about as satisfactory.

We believe, as in some of Dr. Owens' work, that where a fascia strip is fastened to the masseter and is permitted to take on some of the function of contracting, you can get some permanent muscular effect, because you have not traumatized the masseter muscle.

As mentioned before, I do not have enough experience with these muscle transplants to say how long they will survive as such. I believe that a slip of muscle handled in this way, particularly where it is split down, as Dr. Adams explained, will unquestionably not survive and atrophy may be a slow process over a period of two or three years or even longer; but I still believe that in the end, he will again have the same thing as one gets with a strip of fascia.

NEAL OWENS (New Orleans, La.): No method for the correction of facial paralysis offering completely satisfactory support and animation has been developed. The improvement reflected from the use of muscle transplants or fascial transplants incorporated in functioning muscle has been sufficient to be of great comfort to patients with complete facial paralysis. Effort directed toward the development of a surgical procedure which will improve existing methods is worthwhile, if it does little more than to stimulate renewed interest.

Correction of facial paralysis, should entail more than actual support of sagging muscles, because support without reanimation means little comfort to the patient.

In answering some of the questions regarding the fibrosis of muscle slips, I can say that I have observed one case repaired by muscle transplants for about twelve years. One of the first cases recorded was corrected over twelve years ago and that case was corrected by means of muscle slips from the masseter muscle. Three slips were utilized, bringing one to the upper lip, one to the angle of the mouth and one to the lower lip. A satisfactory result has persisted through a period of over eleven years. This patient has been examined regularly from year to year. I have seen him within the past three months and the result is better today than it was two months following the operation.

It has been found, on the basis of experience, that these cases will show definite improvement during one, two or three years. I do not mean to imply that this is a reflection of more power from the muscle but probably is a combination of increased muscle power plus a degree of animation resulting from increased coordination, which is developed as a result of exercises done before a mirror. This is a most important procedure to have patients follow. Unless the patient has the necessary desire to develop animation, which can be attained only through constant exercise and practice,

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the result will be proportionately less. Patients are instructed routinely regarding the exercise of the masseter muscle. By comparing movements which they visualize in a mirror, they learn to develop a marked degree of reanimation.

During a twelve-year period, twelve cases have been corrected. Three or four of those were done by muscle slip transplants, the others were done by fascia transplants, incorporated in the masseter muscle. I was of the opinion that the fascia transplant subjected the masseter muscle to less trauma and for that reason discarded the muscle transplant operation for that one utilizing the transplantation of fascial strips into the masseter. There are three things which one should consider if planning to use a muscle transplant operation: (1) possible injury of the nerve and muscle; (2) the inability of the lip and (3) disturbing or applying too much tension on Stensen's duct.

Patients corrected by means of fascial transplants incorporated in the masseter muscle have been just as satisfactory, in so far as I can evaluate, as those corrected by utilization of muscle transplants. The use of fascial transplants makes a much simpler operation and one that can be approached by the extra-oral route, avoiding the possibility of infection.

PAUL W. GREELEY (Chicago, Ill.): There is one point which I do not believe has been stressed adequately, and one which has always been difficult for me to decide, that is, just what patients should be selected for operation. I have not been able to find any test, either myself or from information given to me by others that will answer this question accurately.

The surprising thing is that many patients who have been operated upon by simple support of fascial strips very soon thereafter appear to have some motion on that side of the face. I have come to believe that many of these individuals have already had a certain amount of spontaneous regeneration of nerve function, which has never been perceptible or complete. Hence, when fascia strips have been inserted in the paralyzed side of the face so as to offset the overpull of the normal side, it is then possible to note a certain amount of motion in the muscles on the affected side, even though it may be slight.

Consequently, I have come, as time has gone on, to operate on more and more individuals with facial paralysis much earlier than I had in the past. I believe if an individual has gone arbitrarily, say,

from three to six months, and has not shown definite signs of a very marked and dramatic return of the function of the muscles from the nerve injury on that side, that one is justified in recommending some type of fascia support operation. This will minimize considerable permanent atrophy from disuse, and at the same time will encourage the patient to utilize what motion remains. I do wish to make it clear, however, that I am speaking of the patient who has a partial return of his nerve function, and not of the individual with a known, permanent, complete paralysis as described by Dr. Adams.

WM. MILTON ADAMS (closing): Thank you, Dr. Glover, Dr. Kitlowski, Dr. Owens and Dr. Greeley. In regard to the question of complete facial nerve paralysis in the cases presented, it was the opinion of Captain Bill Livingston, of the Peripheral Nerve Surgical Department of the U. S. Naval Hospital at Oakland, that the paralysis was complete in both cases and the condition could be improved only by facial suspension or muscle transplantation.

As to the future function of the muscle transplant, my experience has been that it continues to improve. Whether the transplant will or will not function depends upon the nerve supply. Once the nerve supply is destroyed, the muscle atrophies. This has been conclusively proved by army and navy surgeons who have been using muscle substitution in the extremities, particularly the hand. Whether the effect of the operation will be lasting or fibrosis will develop two or three years later likewise depends entirely upon whether or not the nerve supply to the transplanted muscle has been interrupted.

Dr. Owens has pointed out the necessity for daily exercise of the transplant. Without supervised reeducation of the muscles, preferably before a mirror, one cannot expect maximum function. We believe that the use of three muscles gives the patient the best prospect of restoration of function, with a more normal direction of pull. Granted that the nerve supply is ample, the end result will depend upon the patient's persistence in carrying out the prescribed exercises.

\* All the illustrations in this article are published through the courtesy of The Williams & Wilkins Company who published them originally in their journal, ADAMS, WILLIAM MILTON. The use of the masseter, temporalis, and frontalis muscles in the correction of facial paralysis. *Plastic & Reconstr. Surg.*, 1:2, September, 1946.



# SURGICAL MANAGEMENT OF EXTENSIVE AVULSIONS OF SKIN\*

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**E**XTENSIVE avulsions of skin and subcutaneous tissues are not uncommon injuries encountered in association with automobile and wringer accidents. Frequently such lesions become complicated surgical problems demanding extensive plastic procedures and long periods of hospitalization because of improper early management. Although seldom dangerous to life, these wounds are all potentially infected and, unless treated as acute surgical emergencies, inevitably lead to serious complications.

In May, 1939, Alfred W. Farmer of Toronto, Canada, presented before the American Surgical Association four cases of severe avulsion of skin treated by immediate complete excision of all of the avulsed skin, débridement of the traumatized area, removal of all of the subcutaneous fat from the avulsed skin and its replacement as a full thickness skin graft on the denuded area. His results were excellent but it was evident from the discussion of his paper that many considered the method too radical for general adoption.

Our experience with Dr. Farmer's method has been excellent whereas our experience with similar injuries treated by other methods has been most discouraging. Although not infrequently the avulsed skin and subcutaneous tissues appeared not badly damaged and often remained attached to a rather large pedicle, careful débridement of the wound and accurate replacement of the avulsed skin was often followed by engorgement of the skin flaps and gangrene. Occasionally, the skin would remain intact but the attached subcutaneous fat would become necrotic and cause secondary necrosis and slough in the grafted area. Fibrosis and contracture of the subcutaneous tissues were frequent complications. These and other observations associated with the treatment of this disabling injury are recorded in the following case histories and discussion:

**CASE 1.** Mrs. A. A., a thirty-seven year old housewife, entered San Francisco Hospital in April, 1938, following an automobile accident. There was a deep laceration of the palm of the right hand and fractures of the distal end of the right radius, the base of the fourth metacarpal, the navicular and pisiform bones. The skin, subcutaneous tissue and palmar fascia were stripped free of their attachments and avulsed to the base of the metacarpal bones of the fingers. (Fig. 1A.) The flexor tendons, although intact, were stripped free of the surrounding tissues so that they could be lifted away from the volar surface of the hand. The superficial and deep palmar arches were intact. The entire surface was ground full of grease and dirt. The wound was carefully débrided by sharp dissection and by repeatedly submerging the hand in saline solution until all devitalized tissue and contaminants had been removed. The contused skin edges were removed by sharp dissection. After careful hemostasis the wound was closed with interrupted silk sutures. Because of the precarious blood supply to the fingers and thumb, no attempt was made to reduce the fracture of the radius. A pressure dressing was applied and the extremity immobilized in a plaster body spica, extending from the tips of the fingers to the waist with the arm held at 90 degrees flexion at the elbow and 90 degrees abduction at the shoulder. The postoperative course was uneventful. The hand was dressed on the twelfth postoperative day at which time the wound in the palm of the hand was healed. An attempt was made to reduce the fractures but proved unsuccessful because traction caused undue interference with the circulation. This patient was started on early active physiotherapy but, regardless of the fact that the skin remained intact, the subcutaneous tissue became fibrotic and caused considerable flexion contracture of the wrist. Subsequent excision and regrafting of this area produced the final result seen in Figure 1B.

**Comment.** This patient, treated before Dr. Farmer's contribution, demonstrates the advisability of immediate extensive and careful débridement of such wounds to prevent infection. Very careful immobilization is important

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FIG. 1. A, Case I. avulsion of skin and subcutaneous tissue from palm of hand.

for the same reason. Regardless, however, of the primary wound healing and absence of infection, secondary fibrosis of the subcutaneous fat and areolar tissue in this patient led to

contracture necessitating subsequent excision and grafting.

**CASE II.** Mrs. M. R., a thirty-two year old widow, entered Santa Clara County Hospital in September, 1941, following an automobile accident. There was a compound fracture of the right tibia in the lower third and an extensive avulsion of the skin of the anterior, posterior and lateral surfaces of the lower leg extending from a point just below the knee joint to the ankle joint. There was also an avulsion of the skin of the lateral surface of the right thigh. The avulsed skin was attached along the medial surface of the leg throughout the length of the avulsion. The patient was taken to surgery immediately. After extensive and careful débridement of the entire wound the fracture of the tibia was reduced and held by the application of a metal plate. The avulsed skin and subcutaneous tissues were carefully replaced and sutured. Pressure dressings were applied and the leg was placed in traction. Fourteen days later, this patient was transferred to the San Francisco Hospital where it was noted that the entire avulsed skin had become necrotic. It was necessary to remove almost all of the skin of the right lower leg and a portion from the right thigh. (Fig. 2.)

**Comment.** This patient demonstrates the usual fate of replaced skin and subcutaneous tissue. As might be expected, she became a difficult nursing problem and recovered the use of the right lower extremity only after months of hospitalization and extensive skin grafting.

**CASE III.** C. G., a three and one-half year old male child entered San Francisco Hospital in November, 1941, following a street car injury. The



FIG. 1. B, final result after replacement of avulsed flap and secondary excision of scar tissue.



FIG. 2. Case 11. Complete necrosis of avulsed skin and subcutaneous tissue two weeks after replacement without removal of subcutaneous fat.

roller on the catcher on the front of the street car had avulsed the skin and subcutaneous tissue of the entire left ankle and foot, including disarticulations and avulsion of all but the great toe at the metatarsophalangeal joints. There was only a small portion of skin still attached near the ankle joint. Figure 3A through Figure 4B demonstrate the operative procedure undertaken. After the remaining portion of attached skin was removed, the entire skin flap was stretched on a board and the subcutaneous fat removed by sharp dissection. The exposed denuded bone of the toes was removed with rongeurs. The denuded foot was carefully débrided by sharp dissection and irrigated with saline. The full thickness skin graft was carefully sewn back in place. A missing area of skin was replaced with a three-fourth thickness split graft from the right thigh. A paraffin dressing was placed over the grafted area. Moist gauze and sea sponges were applied as pressure dressings. A long leg cast completed the dressing. In order to preserve the great toe this single area was grafted with the avulsed skin leaving the subcutaneous fat in place. Figure 5 shows the foot healed. The initial dressings were not disturbed for two weeks. There was practically a complete take of this graft with the one exception of the great toe where the subcutaneous tissue was left intact. This area became gangrenous, was removed and regrafted.

*Comment.* The excellent result obtained in this patient is an admirable demonstration of the method proposed by Dr. Farmer for the treatment of extensive avulsion of skin and subcutaneous tissue. Had we not inadvisedly left subcutaneous tissue on the skin flap cover-

ing the great toe, in all probability there would have been a complete take of this entire graft.

CASE IV. Mrs. E. G., a fifty-nine year old housewife, was admitted to the San Francisco Hospital in January, 1942, following a wringer injury. Apparently, the wringer had run over the hand and forearm, avulsing completely the skin and subcutaneous tissue of the forearm from the cubital fossa to the wrist joint except for an attachment of the skin posteriorly along the interosseous ridge. The sensations and circulation of the hand remained intact. After careful cleansing with soap and water, ether and alcohol, the laceration about the cubital fossa was carefully débrided by sharp dissection. The loose skin cuff covering the arm was then incised longitudinally on the volar surface of the forearm, forming two equal-sized skin flaps attached on the posterior surface of the arm. The subcutaneous tissues were then meticulously removed from the undersurface of both skin flaps, leaving only full thickness skin flaps. (Fig. 6A.) The remaining portion of subcutaneous tissue was removed by sharp dissection from the fascia overlying the musculature of the forearm. After careful hemostasis, the wound was irrigated with normal saline and the full thickness skin flaps were sutured in place with interrupted silk sutures. Paraffin gauze was applied to the wound with cotton batting and sea sponges held with an ace elastic bandage superimposed as a pressure dressing. The extremity was placed in a plaster cast for immobilization. The wound was dressed on the seventh postoperative day at which time it appeared that about 95 per cent of the grafts had taken. It was noted, however, that the flaps seemed blue and congested and there was a



FIG. 3. A, Case III, appearance of foot immediately following injury; B, avulsed skin prepared as full-thickness grafts by removing all subcutaneous fat.

small area of necrosis on the volar surface of the forearm where the two flaps had been sutured together. (Fig. 6b.) This area of necrosis increased in size during the following weeks and did not heal completely for about four months. (Fig. 6c.)

*Comment.* This patient raises the question of the advisability of preserving the marginal attachments of extensively avulsed areas of skin. One is reluctant indeed to separate attached margins of skin for fear of destroying the small amount of blood supply remaining. However, this patient and others have led us to believe that regardless of pressure dressings

these attached flaps are apt to become congested with arterial blood and, because of inadequate venous drainage, are subject to chronic passive congestion which is detrimental to their preservation. In our experience, attaches flaps denuded of subcutaneous tissue do not do as well as free full-thickness grafts.

**CASE V.** Mr. L. B., a fifty-two year old steel worker was admitted to the San Francisco Hospital in May, 1942, following an automobile accident. There was an extensive laceration of the palm of the right hand with an avulsion of skin approximately about two-thirds of the area of the palm.

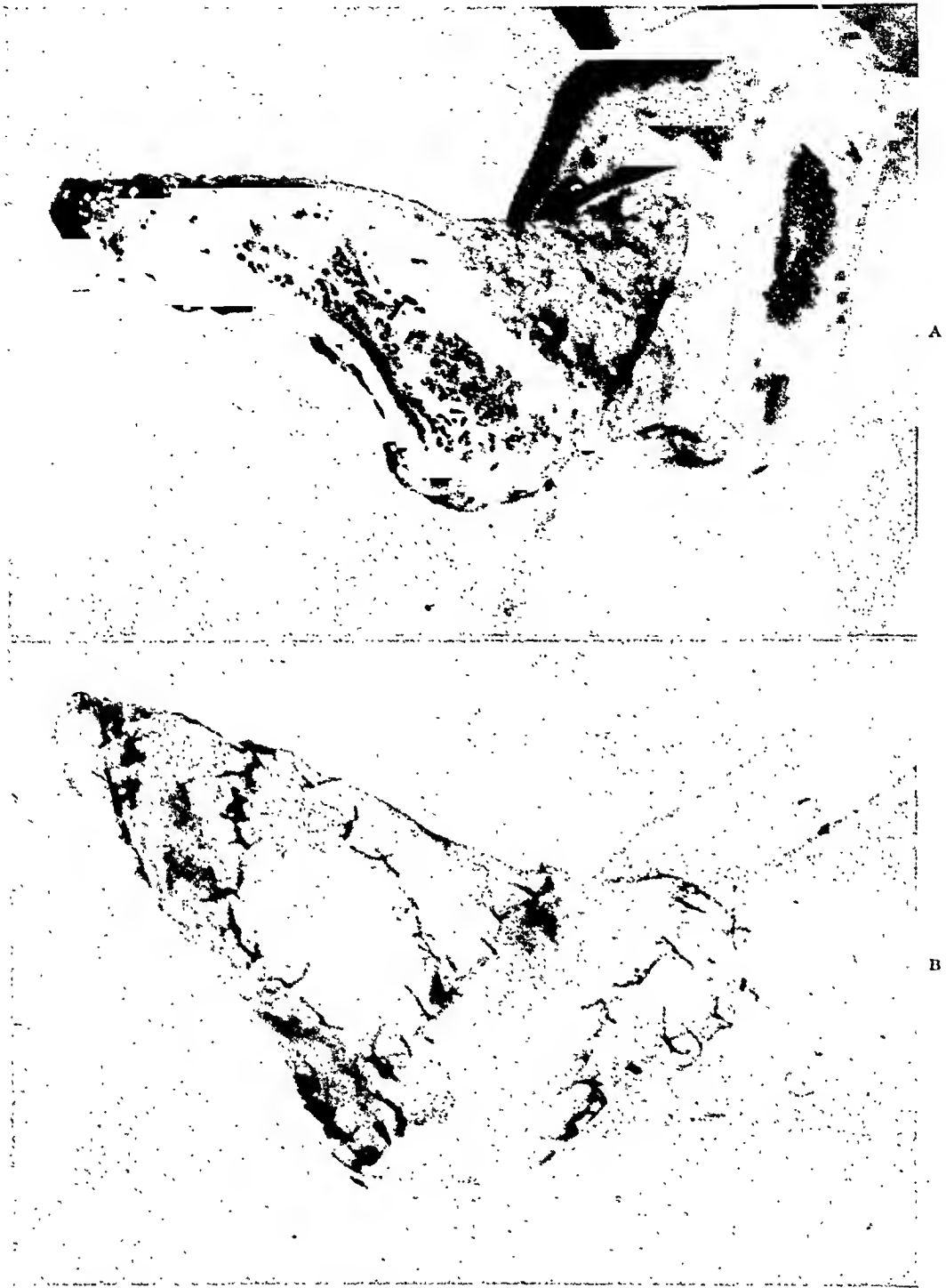


FIG. 4. A, Case III. denuded foot prepared for grafting; B, full-thickness grafts in place.

No tendons or nerves were severed. The right hand was meticulously scrubbed with soap and water and cleansed with ether and alcohol. The skin flap was incised at its base and removed. All of the subcutaneous tissue was removed from the excised skin by sharp dissection. The palmar surface of the hand was débrided carefully and irrigated with saline. After hemostasis, the avulsed skin was replaced as a free full thickness graft. A paraffin dressing covered with sea sponges and an ace elastic bandage was applied. The hand and upper extremity were encased in a plaster cast.

The wound was dressed on the tenth postoperative day at which time it was noted that there was a complete take of the graft. Figures 7A and 7B demonstrate the hand before and after treatment.

*Comment.* This patient had a similar injury, although not complicated by underlying fractures, to the first patient reported. Here the avulsed skin was completely removed and replaced as a free graft. In the first patient, the avulsed tissues after débridement were replaced





FIG. 5. Case III. Final result.

intact. Although the two injuries are not completely comparable, the area of avulsion of skin was the same and the result in this patient far superior to the first.

**CASE VI.** F. J., a two and one-half year old colored boy, entered San Francisco Hospital 7:20 P.M. December 3, 1946. He had been run over by a truck thirty minutes previous to entry. The truck had run over the left lower extremity. There was an avulsive injury of the lower one-half of the left leg and foot, the entire thickness of the skin and subcutaneous tissue being lifted off the fascia, extensor and flexor tendons, leaving the largest flap of skin attached only at the base of the toes on the volar surface of the foot. There was a moderate amount of bleeding. The entire area was ground full of grease and dirt. The entire left lower extremity was cleansed thoroughly with soap, water, alcohol and ether and the large flaps were cut free from the extremity and given to an assistant who thoroughly scrubbed the flaps with

soap and water and removed every bit of subcutaneous tissue from the underside of the skin, leaving the full thickness skin for a graft. The wound itself was thoroughly washed with soap and water, and irrigated with saline so that every particle of dirt possible was removed. All the contused and necrotic tissues were cut away. Bleeding was controlled by pressure. The extremity was then redraped, the operating team changed gowns and gloves and a new set of instruments used for the actual surgery. Numerous thrombosed vessels were encountered. These were all débrided away as well as the contused muscle and subcutaneous tissue. The anterior tibial artery appeared to be pulsating as well as the dorsalis pedis artery. The posterior tibial artery was intact, the tendons were inspected and the only tendon which had been avulsed was the long flexor of the large toe. This tendon was approximated with No. 60 cotton. The skin which had previously had all of the subcutaneous tissue removed was then fitted in place on the foot, covering the entire defect with the full thickness skin graft. The margins of the graft were sutured with interrupted No. 60 cotton sutures. A pressure dressing was applied. On December 12th, the pressure dressings were removed and approximately 60 per cent of the graft had taken. The areas which had not taken were those areas of skin which at the original examination appeared to have been extensively burned by friction. On January 6, 1947, the granulating areas of the wound were covered with split thickness grafts. Figures 8A and 8B demonstrate the wound before and after grafting.

**Comment.** This patient is another who was treated by the method of Farmer. Although approximately 40 per cent of the original graft was lost, the method of treatment was not at fault. It was anticipated that about that amount of the original skin was badly burned and might not survive. That skin should have been discarded and replaced with three-fourth thickness free grafts at the original operation.

**CASE VII.** Mr. E. V., a sixty year old white engineer, entered San Francisco Hospital in May, 1947, following a truck accident. The truck had knocked him down and the rubber tire on one rear wheel had rubbed against and squeezed the tissues of the left thigh and left lower abdominal wall. Examination revealed an extensive laceration in the left groin with an extensive avulsion of all of the skin and subcutaneous tissue of the entire left thigh and left lower abdominal wall. The patient was taken to surgery where after careful preparation of the entire left thigh and abdominal wall, the margins of the laceration in the left groin were carefully débrided by sharp dissection. It was

noted that all of the skin of the left thigh, left lateral buttock and left lower abdominal wall had been completely avulsed from the underlying tissue except along a margin about 4 cm. wide extending from the left groin to the medial side of the left knee. An incision was made from the anterior superior spine of the left ilium to the outer margin of the left knee joint. This incision joined the laceration in the left groin, thus forming three very large skin flaps. One skin flap was turned upward over the abdominal wall and the two on the thigh were reflected medially and laterally to their attachment on the medial side of the left thigh. With the flaps reflected the entire left thigh from the groin to the knee and the entire lower left abdominal wall were completely denuded of skin and subcutaneous tissue. All of the subcutaneous fat was dissected free from these skin flaps by sharp dissection and the underlying wound carefully cleansed by irrigation and removal of all devitalized tissue. The full-thickness skin grafts still attached at one margin were replaced on the region from which they had been removed and sutured in place with quilting sutures of fine silk tied over small pieces of gauze. The grafts were sutured together with interrupted silk sutures and the entire area "pie crusted" with small incisions for drainage. An extensive pressure dressing was applied. The post-operative course was uneventful until the fifth day when the patient developed an extensive ileus, became extremely excited and violent and died in delirium tremens. Examination of the grafted area after death revealed that the full thickness skin grafts all appeared viable and were adherent to the underlying tissues with a thin fibrinous exudate. There was no evidence of infection and it seemed probable that these grafts would have taken had the patient lived.

**Comment.** This patient had the most extensive avulsion of skin that we have encountered. He was treated according to the method of Farmer except that the attached margins of the skin flaps were left attached. The patient's unfortunate death on the fifth day deprived us of the end result of such an extensive primary graft; however, there was every evidence at the time of death that the grafts were attached and living and in all probability would have survived.

#### COMMENT

It may be seen from the case histories reported that our best results have been obtained in those cases in which we have had the courage to remove all of the subcutaneous fat from the avulsed skin and to replace the skin as full

thickness grafts. In the discussion of Dr. Farmer's original paper, Dr. Sumner L. Koch, of Chicago, questioned the advisability of detaching flaps which were attached by a wide margin. Dr. Farmer was opposed to leaving attached margins and stated that the only skin that he had lost was in a case in which the skin flaps were not detached. Dr. John Homans, of Boston, mentioned the possibility of chronic passive congestion developing in attached flaps because of retained arterial blood supply and insufficient venous drainage. In our experience the important factor in this connection is the removal of all subcutaneous fat from the avulsed skin. This can be accomplished most simply by completely removing the skin and having it prepared by an assistant while the wound is being prepared for grafting. Such a procedure will certainly shorten what is often a long and tedious procedure. Furthermore, it seems highly improbable that skin which has been denuded of all its subcutaneous tissue will receive sufficient arterial blood from the attached margins to alter its fate one way or another. We have found it convenient at times to leave the margins attached and as may be seen in Cases IV and VII such flaps do survive. No doubt, those in favor of leaving the attached margins have in mind similar situations produced surgically, such as the skin flaps raised in radical amputations of the breast and in removing the subcutaneous tissues in elephantiasis of the legs. It should be remembered that these flaps are produced surgically with a minimum of trauma, whereas avulsions due to trauma presuppose more or less extensive injury to both the skin and underlying tissue. Two patients in our series (Cases I and IV), in which the skin flaps remained attached, did develop what appeared to be chronic passive congestion of the attached skin. Both flaps survived. However, they might have done better had they been completely detached. The results obtained following complete detachment of the skin have been best and seem to justify the procedure.

There can be little doubt of the advisability of removing subcutaneous fat from the avulsed skin. Regardless of the appearance of this tissue it is usually severely traumatized as is evidenced by the extensive thromboses of vessels encountered in its removal. Although occasionally replaced flaps of skin and subcutaneous fat will survive initially, subsequent fibrosis of the



FIG. 6. Case IV. A, skin flaps denuded of subcutaneous fat; B, skin flaps ten days after suture.

subcutaneous tissue is apt to lead to troublesome contracture with deformity and often results in persistent peripheral chronic edema. Here again one is faced with a difficult decision at the original operation. Excision of extensive areas of subcutaneous fat appears at the time to be an unduly radical undertaking. However, experience has shown the wisdom of such a procedure. Secondary gangrene and infection

of large areas of avulsed tissue as demonstrated in Case 11 is not only dangerous to the life of the patient but the treatment involves long periods of hospitalization and requires extensive surgical procedures for its correction. Case 111 demonstrates the inadvisability of leaving subcutaneous fat attached particularly to unattached skin. In the treatment of this extensive avulsion injury the only skin lost was that small

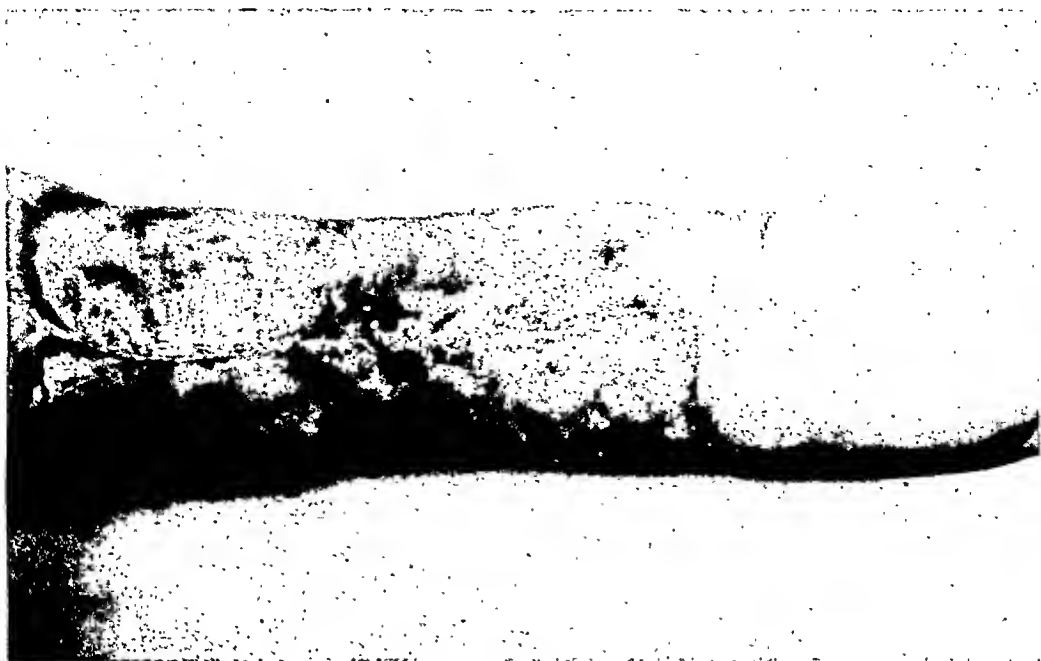
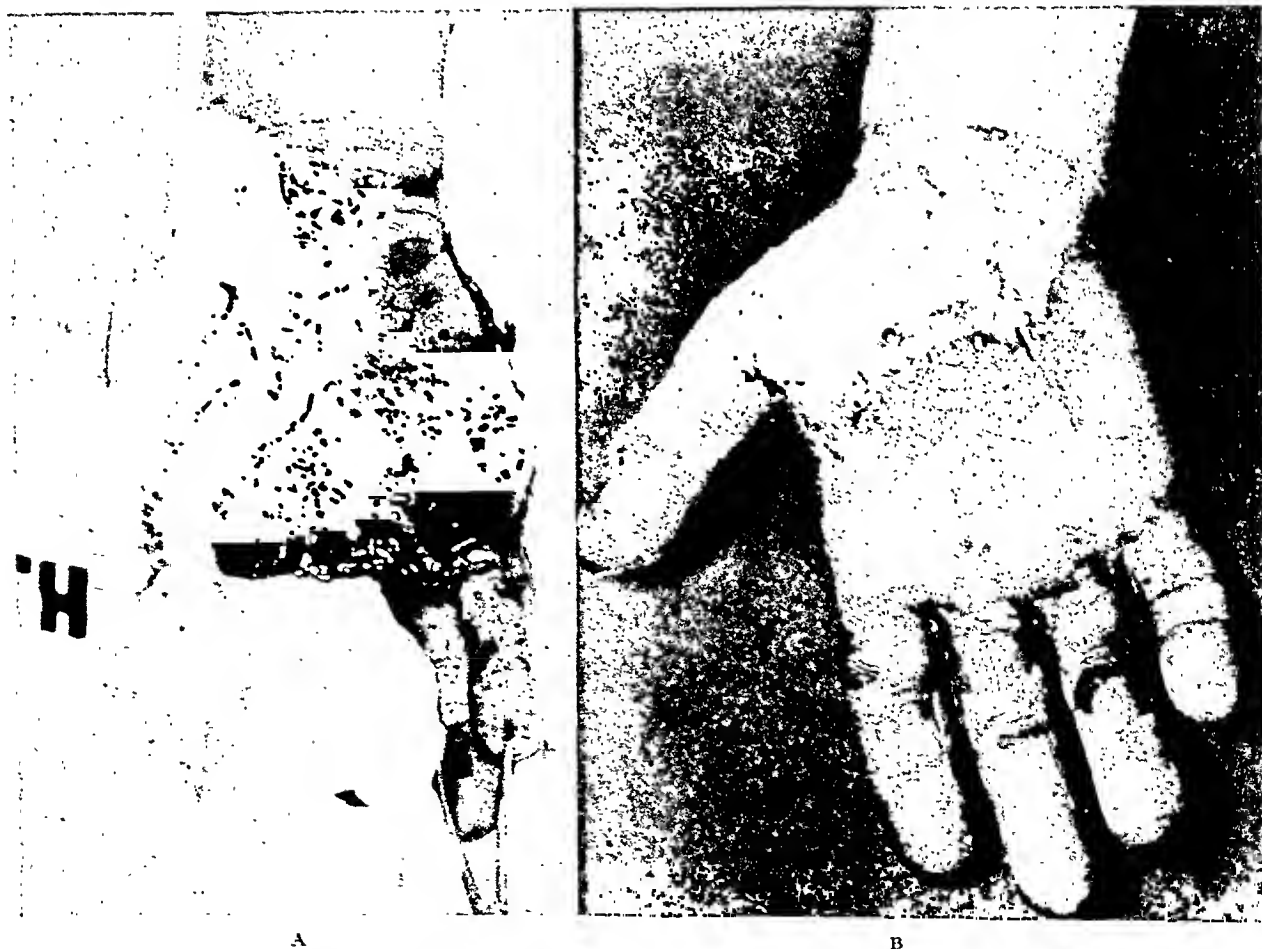


FIG. 6. c, result after four weeks.



A

B

FIG. 7. Case v. A, avulsed skin reflected from palm; B, appearance of hand two weeks after replacement of avulsed skin as a free, full-thickness graft.



FIG. 8. Case VI. A, foot and leg prepared for grafting.

area over the great toe where fat remained attached to the grafted skin.

As was emphasized in Farmer's original



FIG. 8. B, final result.

article, the skin when removed and prepared for grafting need not be handled too carefully but care must be taken that all of the subcuta-

neous fat is removed. This can be accomplished readily by pinning the inverted skin on sterile boards (Fig. 3B) and cutting the fat away with a sharp knife. If the skin has been badly contaminated at the time of injury, it should be cleansed thoroughly by scrubbing with soap and water before it is replaced. Those areas of skin which obviously have been too badly damaged by the original trauma to survive should be cut away from the full thickness graft and discarded. This skin can be replaced at the original operation with three-quarter thickness grafts taken with a dermatome. This is an extremely important step in the procedure inasmuch as necrosis of devitalized areas of skin in the grafted area may lead to infection and jeopardy of the living graft. Case VI demonstrates the fate of devitalized skin replaced as a graft.

Care should be taken that the grafted skin is not overstretched. Overstretched skin will retract, leading to areas of granulation tissue at the margins which will cause the formation of scar tissue and contracture. In placing the grafts, if multiple, one should avoid placing the margins across flexion creases such as the ankle or wrist joint. Skin stretched over bony protuberance such as the os calcis may lead to necrosis if tension is too great. Large grafts in our experience should be perforated at intervals for drainage and should be securely held in place with quilting sutures. Pressure dressings

should remain in place from ten to fourteen days unless evidence of infection develops.

The preparation of the area to be grafted is of equal importance to the type of graft placed upon it. Very meticulous cleansing and removal of all devitalized tissue and absolute hemostasis are essential to primary healing. Unless these patients are treated as acute surgical emergencies, infection in the wound will preclude the possibility of primary grafting. Immobilization in plaster insures proper rest of the injured part during the healing period.

#### SUMMARY

Seven patients with extensive avulsions of skin and subcutaneous tissue are reported with the details of treatment and comments on the final results. In our experience the method of treatment proposed by Dr. Farmer of Toronto, Canada, in 1939, has given the best results. His treatment involved the complete removal of all avulsed skin, careful débridement of the remaining denuded areas, removal of all subcutaneous fat from the skin and its replacement as a full thickness graft to the area from which it was removed. The importance of treating this type of injury as an acute surgical emergency is emphasized.

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#### DISCUSSION

HARRY B. MACEY (Temple, Texas): Dr. Mathewson's paper interests me a great deal, because for several years we have been using a similar procedure in the treatment of chronic lymphedema involving the lower extremities. Even though this latter condition is not traumatic in origin, treatment is along the same line as presented in this paper. By excising the skin, lymphedematous tissue and fascia and applying a thick split skin graft, we have accomplished the same results that was accomplished here. Some of our patients have had a tendency to show some stasis changes in the thick splits especially about the ankle.

The operative procedure we have employed has covered the entire lower extremity from the ankle to the knee. I would like to ask a question: Are there stasis changes, such as thickening and fibrosis in these full thickness grafts that have been reapplied?

ALFRED W. FARMER (Toronto, Canada): I enjoyed Dr. Mathewson's presentation very much indeed. I have noted in our own center that despite the fact that this has been published and used for a long time, certain men who are very conversant with ordinary surgical procedures will not use this one. Why that is, I do not know.

A very well trained surgeon in our own hospital, less than a week ago, asked me to see a hand some days after an injury in which the large portion of the palm had been avulsed. He had sutured it back, leaving the avulsed skin attached at one side. There was a loss of coverage and that is in my own hospital.

The skin does not have to have any wound in it whatsoever to be avulsed. Workmen who have had their forearms pass through rollers will avulse all the skin and subcutaneous fat completely from the forearm or arm, without any wound in it whatsoever, simply by rolling the skin and subcutaneous fat off the deep fascia. A great number of such cases need no such procedure as this at all but some do. One has to judge from the appearance when the wound is seen whether the flap will survive or whether it will not.

Taking the flap off is a formidable procedure. However, nothing can be lost by so doing. You just take it off and take the fat off and put it back on. But those who are not used to doing this find the whole procedure a mental hazard.

Dr. Mathewson mentioned that Dr. Koch questioned the advisability of the procedure. Since that time, Dr. Koch has seen practically all of the cases that were mentioned in that original article and I think he changed his mind. We had them in when he came to pay us a visit.

The procedure has been used not only in patients with injury to the skin alone, but also in lesions in which there have been compound fractures of bone, associated with crushing injuries to the limbs. The bone lesion was handled at the same time with the whole skin being taken off a leg and put back on again. If, as Dr. Mathewson has said, the skin is very badly injured, it is necessary to discard it and use a split skin graft with a section of the skin which you have avulsed.

Dr. Mathewson's presentation was very interesting indeed.

CARLETON MATTHEWSON, JR. (closing): I would like to thank Dr. Macey and Dr. Farmer for their discussion. I had hoped that certain questions in connection with this type of injury might be answered in the discussion of the paper. How large

should the avulsion be before one considers complete removal and replacement as a free graft? I believe that the decision does not depend upon the size but rather upon the blood supply of the avulsed tissue. If the margins of the avulsed skin, when still attached by a pedicle, bleed when traumatized, the blood supply is intact and the pedicle may be replaced. However, completely detached areas of skin should be treated as described before being replaced as a free full-thickness graft.

We have not seen chronic edema develop in these free grafts when all the subcutaneous tissue has been removed. As a matter of fact, chronic edema frequently has been successfully treated by removing the involved skin and subcutaneous tissue and covering the area with full or split thickness skin graft.

The question as to whether or not these flaps should be completely detached when still attached by a pedicle is answered, I believe, by the ease with which they can be handled when completely removed. If a margin is left attached, it becomes extremely difficult to remove the subcutaneous tissue from it. Unless the subcutaneous tissue is removed, a slough or contracture will occur. The blood supply obtained from an attached margin, I believe, is negligible. If you leave the margins attached, you will find in the process of removing the subcutaneous fat that it does not bleed and many of the vessels are thrombosed. As you approach the attached margin, you will find that the subcutaneous fat does bleed and there you may safely stop. The viability of the skin depends upon the blood supply to the subcutaneous fat.





# INTRODUCTION TO MAJOR GENERAL HAWLEY'S SPEECH

FREDERIC W. BANCROFT, M.D.

*New York, New York*

I AM not going to let Major General Hawley, get up yet, because I have something to say about him.

Major General Hawley retired from the Army in June 1946 to become the first Chief Medical Director of the Veterans' Administration. He was first commissioned in the Army in 1916, and during an active service of almost thirty years, he was promoted through the successive grades from First Lieutenant to Major General.

I will not tell you when he was born but it was in West College Corner, Indiana. He received his A.B. degree from Indiana University, his M.D. degree from the University of Cincinnati, and the degree of Doctor of Public Health from Johns Hopkins University. During his Army career, he graduated from both the basic and the advanced course of the Army Medical School, from the Command and General Staff School and from the Army War College.

He has been an instructor in both the Army Medical School and the Medical Field Service School and was the Assistant Commandant of the latter school. Dr. Hawley served in France as a regimental surgeon during the first World War. Between world wars, he served in the Phillipine Islands and in Nicaragua, on the Nicaraguan canal survey of 1929 to 1931, as well as at various stations in the United States.

He was the first commanding officer of the Medical Replacement Training Center at Camp Lee, Virginia, which was opened in 1941. During the summer of 1941, before Pearl Harbor, he was sent to England as one of the special observers with the British. After the United States entered World War II General Hawley became the Chief Surgeon of the United States forces in the British Isles, and afterward Chief Surgeon of the European Theatre of Operations. As head of the Medical Service of the United States Army in Europe, he built or leased hospitals to the total of 203,000 fixed hospital beds. He supervised and directed the Medical Department in the theatre, which eventually reached the strength of 254,000 officers and men, including 16,000 physicians, 4,500 dentists and 18,000 nurses.

General Hawley was awarded the Distinguished Service Medal, Legion of Merit and the Bronze Star by the United States, the Legion of Honor and the grade of Officer, the Order of Public Health and the grade of Commander, and the Croix de Guerre with Palm by France, the Companion of the Bath and the Order of St. John of Jerusalem and grade of Knight by Great Britain, the Order of the Crown and the grade of Commander by Belgium, and the Presidential Medal of Merit by Nicaragua.

He is a Fellow of the American College of Physicians, a Fellow of the Royal College of Physicians of England, an Honorary Fellow of the Royal College of Surgeons of Edinburgh, and an Honorary Fellow of the Royal Society of Medicine of London.

Now, I had all this impressive official information about the man, but I felt that I would like to know something more about the individual, General Hawley, so I tried to find out from various sources. I called up Mather Cleveland because I knew that he had served under General Hawley in England. "Well," he said, "all I can tell you about General Hawley is that we were so damned thankful he was our chief over there that we couldn't say anything else. He was the squarest-shooter and the best administrator that I have ever known." Then he said, "Why don't you read Hawley's article in the last May number of S. G. & O? Don't you keep up with the modern literature?" I confessed, no, I had not read what General Hawley had written. Later that afternoon Dr. Cleveland called me again and asked if I had read the article. Then I looked at the May number. I wonder how many of you have read it, because I learned a good deal of the man, as Mather Cleveland had said I would. He has written something in which you would all be tremendously interested. The title of it is, "Did Cholera Defeat Custer?" From this article, I think you will learn a good deal of the interests of the man. Here is a doctor who has entered into the problem of epidemiology of cholera, of medical tactics, and Army tactics in the Custer campaign, but, above all, I came to the con-

clusion that he condemned dishonesty. God; how I would hate to have him as my enemy! I do not think he would be a very charitable enemy if you were crooked enough to get his dislike.

Then I tried to find out some more about General Hawley. I found that his father and his grandfather had practiced medicine, but I also found out that in addition to practicing medicine in Indiana, they had been interested in hogs, and I found out that General Hawley at present has a son who raises hogs, and General Hawley has an idea that when he gets out of this job, he is going back to Indiana and raise hogs, which, after all, is a good estimation of the man.

I also learned from other sources that when he first went to England, he had a habit of going down to the pubs along the waterfront, where he learned an authentic cockney accent, where he learned a good deal about the problems of the common man in England, and where his influence made the common man of England think a lot more of our commanding medical officer.

Now, my personal relationship in respect to U. S. Veterans' Hospital No. 81, which is now called the Bronx General Hospital, is this: It happens that I have been consulting surgeon up there for more years than I would like to admit, and I would like, in a way, to draw a comparison of the pre-Hawley and pre-Magnuson days with the post-Hawley and post-Magnuson days, and I am afraid that all I may say of the past is not entirely complimentary.

When I first went to the Veterans' Hospital, it was a hospital of 1,200 beds. It now has 1,800 beds. It was manned by Veterans' Bureau men, who were civil servants. They came at nine and they left at five. When it was a 1,200-bed and later an 1,800-bed hospital, they had only two doctors on duty at night and over weekends. These two were not surgeons because they had to learn the details of admitting veterans. At that time, we had some swell surgeons up there, men who were in the Veterans' Bureau, but the system bogged them down.

I became very much perturbed about this situation, because it did not seem fair to me to have men do major operations, then have their extra time taken up with paper work so they could very rarely see their patients. There was a higher mortality than there should have been. Therefore, I went to Dr. MacEachern of

the American College of Surgeons and I said, "You ought to send your hospital representative to the Veterans' Hospital to see if something cannot be improved, and if it cannot be covered by more men." He said, "You write a little note and put it on my desk."

I took a piece of scratch paper and I wrote, "Dear Mac: There are only two officers on duty, officers of the day, at the Veterans' Hospital over weekends and at night, and the mortality over weekends would cause a riot in the ordinary American civilian hospital." Well, Dr. MacEachern took that note in my handwriting and put it on Dr. Hines's desk, and Dr. Hines sent it with a caustic note to the Veterans' Bureau manager at the Bronx Veterans Hospital, and I was called on the carpet. However, it was worth while, because I did get six men, three of whom were surgeons, on duty at night and over weekends during this attack. Now we have fifty residents for these periods.

During my early time at the Veterans' Hospital, there was the most beautiful isolationist practice you ever saw. I wanted to get Dr. Allen Whipple to come up one day and make surgical rounds. I went to the manager and he said, "These boys are patients of the United States Government; they should not have anybody seeing them besides their own doctors, and they should not be made clinical examples." One would almost have needed a special Act of Congress to bring a visitor up there to make rounds.

The manager would not allow the younger men to go to meetings or to take special courses in New York City because he said these men were serving the boys of the Government, they were paid to serve the boys, and they could not have time off to do any foolish things like that.

That is what it was like before the present era.

Right here, I should like to pay a tribute to what has happened, because I have seen it happen and I have seen it happen after having tried for years and years to make the change. You all know what they are doing and it is unnecessary for me to tell you, but I would like to say a little bit about our experience in New York.

In the first place, the Deans' Committee appointed the senior surgical consultants and they did it by making all of the past consultants resign and then they appointed the men whom

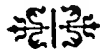
they thought best fitted to carry out their new program. It was the job of the consultants to recommend to the Deans' Committee the various attendants.

We have never had one political suggestion that we appoint a man as an attending surgeon or attending physician. It was left without any political suggestion to the consultants, and the consultants' only trouble was that the Deans' Committee might not approve or not think they were doing as well as they should. But so far as the Veterans' Bureau was concerned, there was no political interference. It was the same way when we started our Resident Program. That was a heartache to all of us. In general surgery, I think we had about 110 well trained veterans who wanted twenty jobs, and it was an awfully tough job to turn down over a hundred men and try to pick, with as little knowledge as we had, those whom we thought were the best men. Nevertheless, there was no influence from any source brought to bear on us, and I persuaded the Deans' Committee that they appoint Dr. Whipple and Dr. St. John also as senior consultants at the Bronx General, and all of us, if we fail, fail because of our inability to judge men or inability to chart a program and not because we have had any political bonds put on us in any way whatsoever.

I think that at the present time, we have established in this hospital—and I know that any number of you men have in others—a good resident teaching system. The men who are preparing for their Boards are freed from clinical work so that they can take the basic sciences, and the others are being well trained in clinical surgery. I saw a senior resident the other day who, by himself, had done a complete gastrectomy and had done a beautiful job. We are trying to teach them honesty in surgery in that once a week Dr. Whipple, Dr. St. John and I, in general surgery, have a conference in which each surgical division tells of its list of operations, the interesting cases, the casualties, infections and complications, and we hold them pretty definitely to it. We finally have gotten them to the point where they will admit errors in diagnosis, which is very difficult to do, even to where an error is made between direct or indirect inguinal hernia.

We think, therefore, we are starting a program which we hope that Dr. Hawley approves. I heard indirectly that Dr. Whipple, who, as you know, was Professor of Surgery at Columbia, said the other day that he thought the best resident training in New York was at the Veterans' Hospital.

Ladies and gentlemen, I give you General Hawley, who is responsible for all of it!



# ORGANIZATION AND CARE OF BATTLE CASUALTIES

MAJOR GENERAL PAUL R. HAWLEY

*Washington, D. C.*

I DO not think it is necessary to explain this laryngitis which is a matter of about twelve hours, but I am as sorry for it as you possibly can be.

This, fortunately for me, seems to be Cincinnati Night, what with Ralph Carothers, and the man who taught me all the surgery I know—my good friend, Hegner, here—which is the reason why I never made a surgeon out of myself, and myself—all from the University of Cincinnati. More power to us and may this happen more frequently!

But I think, in all honesty, we should correct some remarks. Dr. Carothers said that he was one of the organizers of this Society, and had never hoped to be President. Well, that's bunk, of course. Nobody ever worked to organize a medical society without knowing that eventually he was going to be made president.

I did say, while I was sitting here and eating my dinner, and I said it seriously, that I think this is one of the most important societies in American medicine because trauma is certainly the most important universal thing which confronts every surgeon, and it is becoming more and more important in the field of surgery.

As regards the progress of the Veterans' Administration in the past eighteen months, I want to say very frankly that we are still very short of our goal. We have made progress and the progress we have made has been due to the great men in the profession who have come to us, full time and part time. I shall not attempt to mention them. I have met so many here tonight that if I attempted to enumerate them, I should forget someone. But I should like to mention the men at the head table, Dr. Bancroft, on part-time, who has taken so much on his shoulders in the Bronx, and Paul Magnuson, who is the spark plug in my own central office organization. And then I could go down the line and pick people that I am proud of, and that I know you are proud of; and such progress as we have been able to make has been due entirely—I would say entirely—to the contributions of those people.

Those of you who have been forced into

medical administration—and I was one; I practiced medicine for seventeen years in the Army until I was forced into administration—those of us who were forced into administration realize that our only reason to be is to give the sort of administration which will exploit to the fullest the great medical talent in this country.

Two nights ago, I had to speak before a symposium which was organized by the Surgeon General of the Army, and which brought to Washington some very distinguished people in the American medical profession. I gave, I am afraid, a rather unpopular talk; in fact, I considered myself fortunate that the listeners did not start throwing water tumblers at me before I left. But the entire theme of my talk was that never in the history of our country (and I think this is true of any country) have we in the Regular Army given a quality of leadership comparable to the great quality of professional talent that comes into the Army in time of war. And since circumstances force us in the Regular Army to plan the organization best to exploit this talent, it behooves us, before the next war, to develop a system which will train the Regular medical officer to give the kind of leadership—well, leadership is a bad term—to give the support and the organization that the great profession of the country deserves, when it comes into the Army; and I hope we can do that.

Now, I would be presuming if I attempted to talk to you tonight technically upon the surgery of trauma, notwithstanding the great efforts of my friend, Dr. Hegner, to make me a surgeon. If I were a surgeon, I could draw heavily on my observations in the European Theatre and perhaps make a rather learned speech upon the technic of the surgery of trauma. But it would be entirely from observation, and I should like to talk to you briefly about the organization which is necessary in the care of trauma in large quantities.

There are three essential elements in the care of battle casualties: The first is personnel; the second is equipment; and the third is supply. If you have those three elements in adequate

amounts, you can treat all the battle casualties in the world.

However, none of these essential elements is of much value alone; and to be effective, all three must be coordinated through organization. The amount of organization required is in direct proportion to the daily casualty rate. Where casualties are very few in number, as in the case in the average civilian experience, little organization is required other than a hospital and its staff and an ambulance to call. Any more complex organization than this for the purpose of speeding the patient to the surgeon would be uneconomical. Facilities would be idle for hours and days, waiting for something to happen.

However, when casualties are occurring at a rate in excess of 5,000 a day, a plan of such simplicity is of little use. In the first place, casualties occur in places where it is impossible to telephone for an ambulance. In the second place, they occur in such numbers that it is impossible to provide enough ambulances for individual calls, and such ambulances as are available must carry several patients each trip. This makes it necessary to collect in groups casualties near the front, so that all ambulances may be filled promptly.

In the third place, hospitals cannot be located as near the scenes of injury as they can in metropolitan areas, and there is often a considerable time lag between injury and surgical attention during which emergency care and treatment must be provided at all times.

In the fourth place, because there is always some limit to the surgical talent available, and because casualties occur more or less at irregular intervals, it is not always possible for the surgeon to attend each patient the moment he arrives at the hospital, and some degree of organization is required, both for the sorting of cases according to their urgency and for the support and care of those who must wait for treatment.

In many respects, the immediate first-aid treatment given a battle casualty is the most important of all the treatments that he gets. If effective first-aid treatment is not immediately available, a considerable proportion of battle injured will die rather promptly from hemorrhage or from shock, and the wounds of a larger proportion will become dangerously infected before they can be properly cared for in a hospital.

Now, prior to World War 1, there was a very

limited unit medical service in our Army, and the British went through World War II with the type of unit medical service which we used in our Army in the Civil War. This limited unit medical service consisted of a doctor and one or two enlisted men of the Medical Department with each combat battalion or similar unit of the fighting forces, whose function it was to establish a first-aid station at a short distance behind the firing line. Combat soldiers were somewhat perfunctorily trained in first aid, and litter bearers were detailed from the combat troops.

This system has several basic defects: In the first place, since the greater part of the training of combat troops must be devoted to their business of killing, it is never possible to train combat troops as well in first aid as it is a medical soldier to whom this is his principal business; so the training of the combat soldier in first aid has never been fully satisfactory in our Army or, I think, in any army. In the second place, certain first-aid technics, such as the highly important one of applying a Thomas splint, are so difficult that they require long training and constant practice, and this is too much to expect of a combat soldier.

In the third place, unless litter bearers are well trained, casualties are often handled very roughly, which not only adds to their discomfort but also invites the onset or the increase of shock. There are also the disadvantages to the combat troops with such a system. The detail of combat soldiers as litter bearers reduces the fire power of the unit and encourages skulking and straggling.

And so, prior to the first World War, the unit medical service of our Army was increased to provide not only for a detachment to operate the unit aid station, but also for litter bearers at the front. However, still under this augmented system in the first World War, the combat soldier was relied on to administer his own first aid prior to the arrival of a litter squad.

Now the recognition of the importance of immediate first aid, expertly applied, and of the impossibility of attaining this with combat soldiers, prompted further expansion of the unit medical service of our Army before this last war, to include a first-aid man in the Medical Department for each combat platoon. These company aid men, as they were designated, while assigned to the unit medical service, were

attached to the platoons that they served; and they lived and they died among the combat soldiers. Expertly trained in first aid, as brave as the bravest, they did a magnificent job in the European Theatre. They saved thousands of lives, and their ministrations under fire on the battlefield were no small contribution to the great reduction in the fatality of battle wounds during this last war.

Some 2,500 of these splendid medical soldiers were killed in action, and approximately 10,000 were wounded. They were awarded decorations for valor out of all proportion to their numbers. Many received the Distinguished Service Cross and at least one, and while I am not certain, I think there are now two were given the Congressional Medal of Honor. The medical profession should be very proud of these fine soldiers.

Except for modifications made necessary largely by improved means of transportation and, to a lesser degree, by the different tactics employed in this last war, the basic organization of the remainder of the medical service of the European Theatre was the same as in the first World War. One heard much talk early in the war that radical changes in medical organization were necessary to meet the changes in armor and armament and the increased mobility of the combat troops. Where such radical changes were tried, the results were poor; and the experience of this war proved, to my satisfaction at least, that the old and established principles of casualty evacuation are as sound today as they were in the Civil War, during which they were developed, and that it is only the application of these principles that must be modified to meet the changing conditions of combat.

Prior to this war, it was a rather fixed principle that evacuation hospitals must be located at a rail head or other forward terminus of a transport system. In Europe, in this war, the rail lines were so damaged by our own Air Force that they could not be repaired as rapidly as our Armies advanced, and motor transport had to be used for great distances to supply the troops near the front. To have located evacuation hospitals always at rail heads would have placed the great majority of them so far to the rear that they would have been useless for the early definitive treatment of casualties; so they were located to be of best service to the troops. Ambulance evacuation supplied the link be-

tween them and the rail heads when rail transport was used.

The use of air evacuation made necessary the location of evacuation hospitals, or field hospitals substituted for evacuation hospitals, adjacent to such air fields as were designated for air evacuation. However, and here is the important point, the basic principle which had been established years before was not that the evacuation hospital must be located at the rail head, but that it must be located where casualties must be collected in considerable numbers in order to fill transports of larger carrying capacity, such as a hospital train. As both air transport and convoys of ambulance companies provide transport of large carrying capacity, the basic principle of the location of evacuation hospitals was observed in the European Theatre.

It must be remembered only that the evacuation hospital *receives* its casualties in single ambulance loads from scattered units on the front, but that it *evacuates* its casualties in large lots to one single destination in the rear, usually to a fixed general hospital; and this is the consideration that governs the location of an evacuation hospital.

Now, to summarize, the principles of the care, of the treatment and of the evacuation of battle casualties that were followed in the European Theatre, were these:

First, the prompt and effective first aid at the very spot at which the soldier was wounded, administered by a well trained soldier whose only duty this was.

Second, the removal of the casualty from the field to a unit aid station as promptly as possible, under his own power if he could walk without danger, and by a trained litter squad when he could not walk without danger.

Third, professional attention at the unit aid station limited to emergency treatment to save life or limb, and to support the patient until he could reach the next station to the rear.

Fourth, evacuation to the division clearing station by ambulance, where it was possible to get the ambulance to the aid station; and, otherwise, further litter carry to a collecting station where ambulances were loaded.

Fifth, a more thorough examination at the clearing station. If in urgent need of surgery, immediate transfer to a field hospital located hard by the clearing station, where an expert surgical team was always on duty. If able to

stand further transportation before surgery, evacuation by ambulance to an evacuation hospital, some ten to twenty miles to the rear where expert medicine and surgery were always available.

Sixth, after recovering from any necessary emergency surgery in the evacuation hospital, or when able to travel without surgery, evacuation by air or by rail to a general hospital many miles behind the front line. It is evident that the average casualty passed through at least three medical units where he may have received treatment before he arrived at a general hospital in the rear, and that the more serious cases were sent back to the United States for completion of their definitive treatment.

Now, this change of hospitals and of surgeons created a problem that is not often encountered in private practice in the case of traumatic injuries. This was the problem of insuring continuity of the same method of treatment throughout, or at least as long as the patient was in the European Theatre. In private practice, the surgeon ordinarily receives a patient at once in the hospital and cares for him until he recovers. Take the treatment of fractures, for example, some surgeons prefer one method and some another. Some are expert in one method; others are not. But when several surgeons in turn undertake the care of one patient with a fracture, it is important that each follow much the same method; and, to make this possible, the method must be prescribed and it must be one that every surgeon is capable of following, whether or not it is his own method of preference.

For example, some surgeons prefer the Roger Anderson apparatus in the treatment of selected fractures of long bones. In the hands of surgeons experienced in the use of this apparatus, it is undoubtedly efficient. But the majority of our surgeons in the European Theatre had never used a Roger Anderson apparatus. Others of our surgeons came to Europe preferring internal fixation in the majority of fractures of long bones. But not all of our surgeons were experienced in this method; so we prescribed suspension traction for the routine treatment of fractures of the femur, for example, because this was a tried and proved method familiar to all competent surgeons. Most of our surgeons recognized the necessity for such restrictions and accepted them graciously, even if they did

not always agree that the methods we prescribed were the best methods.

So much for the general organization for the care of battle casualties.

We can dismiss equipment with a word. In general, our equipment was ample in quantity and first-class in quality. I cannot remember ever hearing a real complaint about the medical and hospital equipment furnished to our Army. A few ingenious improvisations here and there added to its efficiency, and some of these improvisations will undoubtedly be manufactured and supplied in the future.

The other important element in the care of casualties is supply. I think that no medical officer who served in the European Theatre would dispute seriously my assertion that our medical supply was the finest in the history of warfare. This is not to say that every medical officer at all times had every gadget that he would have liked to have had; but it is to say, rather, that no hospital was ever handicapped by a shortage of essential supplies.

The organization for supply was a difficult and intricate task. Medical supplies are small in bulk and were usually shipped from the United States as what was called "filler" cargo, together with shipments of arms, ammunition, engineering materials and vehicles. They were put in the cracks and crevices between the heavy materials that had to be shipped in the holds of ships, so that they arrived scattered among many shipments which were unloaded in many ports at different times. Now, at times, supply ships were backed up in harbors to the number of several hundred, and they were unloaded on a priority basis determined by the need for their principal cargoes. For example, a ship might be loaded with 10,000 tons of bridge materials and 100 tons of medical supplies. If there were no immediate need for the bridge materials, the ship would not be unloaded regardless of our need for the medical supplies that were aboard. Occasionally, if our supplies could be got at easily, we could get them off such a ship by lighter, but that was the exception rather than the rule.

While at first all of our medical supplies were unloaded in England, as soon as the French ports and the Belgian and Dutch ports were opened, some were unloaded in one place and some in another, and we never knew when a ship came from the States in which port it would eventually be unloaded.



Supplies had to be consigned to the various depots from the ports, and we had eighteen or twenty medical depots throughout the theatre; so it required a high order of ability and industry to keep the large stocks balanced in all depots at all times, with the incoming supplies arriving all over this part of Europe.

Then there was the problem of medical supply for the initial landings on the Continent. No one knew how many ships would be sunk in this difficult attack, or what ships would be sunk. We expected terrific casualties among these ships. We expected to lose a large number of ships in this first attack on the Continent.

Had supplies been sent in this attack in their original classified containers, such as we received them—which were boxes of dressings, boxes of morphine, cases of ether—had we just taken those and attempted to ship them across to the Continent during the landing, when one ship went down it might have carried all of the dressings that we had, or all of the ether or all of the morphine; and so, to prevent such a disaster, we repacked our medical supplies in large waterproof units on skids—something like the farmer's sled that he uses to haul water out to his hogs—and I hope all of you know what a hog is, since I have been identified with it. We had large skid loads of supplies that could be hooked to a truck or tractor and dragged; and by test, we found that we could dump them in the ocean and for three days there would not be a bit of leakage. We could salvage them from under the water, completely submerged, and the dressings would be dry and nothing else spoiled. And so we repacked all our medical supplies for the invasion on these unit skid loads.

Each one of those unit skid loads contained a balanced stock of drugs, dressings and other things needed for the treatment of 1,000 casualties of all kinds. We estimated how much of this and of that would be necessary to treat 1,000 assorted casualties—how much morphine, how much ether, how many dressings, how much castor oil, for example, or how much salts—and we packed those in unit loads.

And so with this system, if a ship went down with skid loads on it, there was no one item lost in its entirety, and every skid load that got ashore carried a balanced stock of all of the essential items. When we got word of the sinking of a ship that had ten skid loads on it, we had only to put ten more skid loads on the next

ship that went over and thus we always had a balanced stock of medical supplies on the beaches.

This was an improvisation which we developed over there largely as the result of the work of my own supply officers. And speaking of improvisations of that kind reminds me of a story which I will tell, with due apologies to several of my friends who have heard me tell it before; but since my stock of stories which can be told in an audience of this kind is rather limited, I shall have to repeat it.

Remember that this is a story of improvisation. This is the story of a British Land Army girl who had been raised in London; and, when the call came to go out and work on the farms, these Land Army girls did a perfectly magnificent job. This girl went out on a farm. She had never seen a farm or a hog or a cow; and many of the chores that she had to do were quite a trial to her. She had a lot of learning to do.

She went to the village "pub" one night with a group of friends and stayed longer than she was accustomed to, and drank more beer than she was accustomed to, and went home very late. She had to get up the next morning at the usual time of four o'clock. She got up with a headache and a bit of a hangover; and, feeling very badly, her first chore was to milk the cow. She went out and, never a very good milker and with an extra handicap this morning, she was making very heavy weather of milking the cow and not getting very much milk. Finally the cow became discouraged and turned around and said, "Now, never mind, dearie, I know just how you feel. You just hold on, and I'll jump up and down."

To me, the distribution of fresh whole blood was the most dramatic accomplishment of medical supply in the European Theatre. In common with the majority of the medical profession at the outset of the war, we had the impression that reconstituted plasma was an acceptable substitute for whole blood in the majority of cases of trauma. British reports of the fighting in the desert confirmed this opinion of ours. Consequently, our original plan was to furnish about one pint of whole blood to each five pints of plasma at the front.

However, our small experience with Air Force casualties in 1942, when we were only fighting in the air in Europe, led us to increase the proportion of blood in our supply plan; and our blood bank in England was set up initially

to furnish about three hundred pints of whole blood daily. This, we estimated, would furnish about one pint of blood to each three pints of plasma used. However, as soon as we landed in France, the demand of our surgeons for whole blood was much greater than we had anticipated.

I went personally to the front to see whether or not our surgeons were calling for whole blood when plasma would have sufficed. I was soon convinced that no more blood was being used than was necessary, and that in many cases plasma was not an acceptable substitute for blood. We immediately doubled the capacity of our own blood bank in England, but it was evident that between 700 and 750 pints per day were the ultimate limit of the possible production in the European Theatre.

We were collecting this blood largely from supply troops. We collected very little from the British civil population, because the British had a blood bank program which was taking most of the blood from their civil population; and so we had to depend upon our supply troops in the back areas. But, as our supply lines got longer and longer, with the same number of troops, the supply troops became thinned out, and it was very difficult to get very much blood in any one place; and this difficulty of collection of whole blood among our troops limited the amount of processed blood which we could produce in our own blood bank.

As the strength of our forces was constantly increasing on the Continent, we could see where our own production of blood would satisfy less than half of the demand for whole blood; and so General Elliott Cutler flew back to the United States and arranged for the shipment by air daily of a thousand pints of whole blood from the States. And this, together with our own production, gave us a daily supply of some 1,700 pints of whole blood. This proved adequate, but never excessive.

Blood was distributed to forward blood banks by air, in iced containers of the thermos-bottle type; and from these forward blood banks the field and evacuation hospitals received it by motor transport.

Rarely was a hospital out of blood, and then only for a few hours during which they were able to obtain plenty from volunteer donors on the spot.

Now, one of the first, the very first, vehicles

that went ashore on the Normandy beaches was a refrigerator truck of our own blood bank; and, with the beach swept by enemy fire, the driver of this blood bank truck persuaded an engineer soldier on a bulldozer to dig a foxhole in the sand large enough to submerge the entire refrigerator truck; and there our truck stayed, right in the middle of the battle on the beach head, supplying the field units around it with all the blood that they needed.

I have not touched upon the organization of general hospitals for the reason that they are quite similar to those in civilian practice. However, there is one more important element that must be taken into consideration, and that is that the great number of general hospitals required results in a shortage of certain critical specialists. In the European Theatre, there were never nearly enough competent ophthalmologists or neurosurgeons, for example. Fortunately, our original plan had located general hospitals in centers of six to twelve general hospitals in one area, and we could place one of these critical specialists in one of the hospitals of the center, and then sort our cases in that specialty all to be sent to that one hospital, in the interest of best utilization of professional talent.

Now, before I close, I want to offer a suggestion for the better utilization of expert professional personnel at the front in the next war, if we are so unfortunate as to have one. At any one time, certain hospitals at the front will always be swamped with casualties and others in the quieter sector will have very little to do. Also, after an attack has moved on and there are no new admissions to a field hospital, its work until it is able to close, is limited to after-treatment of the patients who have been previously operated upon; and the need for expert surgeons is thereby greatly reduced. These facts point the need for the greatest possible flexibility in the organization of the professional personnel at the front. Some of this flexibility was furnished in this war by the auxiliary surgical groups, one of which was assigned to each Field Army. From these groups came all the surgical teams that did the surgery in the field hospitals, and which reinforced evacuation hospitals whenever they were overloaded.

Now, this was fine so far as it went, but there still was a lot of fine surgical talent that was frozen in the fixed Tables of Organization of

evacuation hospitals and which, in my opinion, could have been used more effectively if it also had been in the auxiliary surgical groups.

Then there was the need for other teams, such as teams specially trained in after-treatment, which could have relieved the surgical teams in field hospitals after all the surgery had been finished and the patients were convalescing, to the point where it was safe to evacuate them to the rear.

And so, I would take most of the professional talent out of the evacuation hospitals and place it in auxiliary surgical groups, leaving only the chiefs of service and a skeleton professional organization in the permanent unit; and I would attach professional teams, medical as

well as surgical, to the evacuation hospitals in accordance with the needs at the moment.

In conclusion, I would repeat what I have often said in public, that the work of the American physicians and surgeons in this war was simply superb. I am terribly proud of the American medical profession. But this vast reservoir of talent would have been largely wasted had there not been an organization which could properly exploit it; and so, for the proper care of battle casualties, the essential elements are good doctors, good equipment, good supply, and last but not least, a good organization that will bring these three elements together with the patient before it is too late to help him.



# TREATMENT OF FRACTURES OF THE OS CALCIS BY OPEN REDUCTION AND INTERNAL FIXATION

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OUR thinking concerning fractures of the os calcis can be expressed in the form of a syllogism, the major premise of which is, "in fractures of the os calcis anatomic reposition cannot be obtained," the minor premise that "without good anatomic position function is impossible," thus the conclusion being that "in fractures of the os calcis it is impossible to obtain good function."

This attitude will be borne out by reviewing our own cases, or by asking any surgeon what his results are in so far as function is concerned, or by noting the number of contributions appearing in the literature during the past ten years, bearing the title "a new method of treating fractures of the os calcis," or by the statement of Willis C. Campbell that "malunion in fractures of the os calcis is so common as to be almost the usual result."

This attitude culminated this past year when Kenneth H. Pridie of Great Britain advocated the excision of the posterior tuberosity in comminuted fractures.

The high percentage of permanent partial disability has been one of our most distressing problems and in an effort to obtain a solution we have now reduced three fractures by open reduction and have maintained the reposition by internal fixation with results which I suggest refute the conclusion of the syllogism which I previously stated.

The os calcis is fractured more frequently than any of the other tarsal bones and in various series these fractures comprise 1 to 2 per cent of all fractures.

## ANATOMY

There are several considerations of the anatomy which are helpful in planning the treatment and which add to an understanding of the fracture.

There are five articular surfaces, each one playing an important part in carrying the body weight in certain positions, in permitting motion and in adapting the foot to certain positions. For example, the subastragaloid joint

permits lateral tipping of the foot to adjust it to uneven surfaces. Thus an arthrodesis results in a disability for walking on rough or uneven floor or ground.

The bone is largely cancellous in structure, the outer surface consisting of a thin, brittle cortex. The spongy structure provides an elasticity in weight bearing. It is dense enough to contain and hold a screw or nail used as internal fixation.

To the inner side is a shelf of bone called the sustentaculum tali which provides an attachment for the medial ligaments of the ankle joint and support for body weight, and at its anterior portion provides insertion for the inferior calcaneosephoid ligament which adds support for the mid-tarsal region and springiness in walking.

The upper surface of the tuberosity runs obliquely downward from the edge of the posterior subastragaloid articulation, and lines drawn from this point anteriorly to the anterior rim of the anterior subastragaloid articulation, and posteriorly over the superior surface of the tuberosity will bisect to form an angle of 40 degrees. This is known as the tuber-joint angle. In the typical comminuted fracture the two lines become parallel, and a restoration of the normal angle is essential if a good reduction is to be obtained.

The depression of the sustentaculum tali when fractured carries a portion of the medial ligaments forward, a portion posteriorly, thus exposing the subastragaloid joint and permitting reduction at operation under visual control of the articular surface.

In 1940, Arthur Steindler stated that: "In fractures of the os calcis, the disability may be not so much to malunion as to the indirect effect of the fracture upon the lateral balance of the foot, due to involvement of the subastragaloid articulation and the traumatic arthritis which develops. The tendency to joint disintegration is lessened by good anatomical reposition. If pain persists, however, the treatment is a subastragaloid arthrodesis."

Because of the difficulty of complete reduction by closed manipulation, some clinicians perform an immediate arthrodesis of the subastragaloid joint and some add an arthrodesis of the calcaneocuboid joint.

#### CLASSIFICATION (KEY AND CONWELL)

1. Avulsion fracture of the tuberosity or separation of the apophysis.
2. Fracture of the medial and lateral processes of the tuberosity.
3. Isolated fractures of sustentaculum tali.
4. Fractures of the body of the os calcis.
  - a. Fracture with eversion of the tuberosity.
  - b. Fracture with upward displacement of the tuberosity.
  - c. Telescoping fractures with lateral mass driven up under the external malleolus.
  - d. Comminuted fractures into the subastragaloid joint.
  - e. Comminuted fractures of the anterior portion of the body into the calcaneocuboid joint.

To the above listed types should be added the more recently recognized march type of fracture. This is characterized by a painful heel, a line of healing being distinguished after several weeks by x-ray study, the line of fracture not extending through the cortex.

#### PATHOLOGY OF FRACTURES OF THE BODY OF THE OS CALCIS

Due to the fact that when the foot strikes the ground it is usually pronated with the tuberosity of the os calcis directed outward, backward and downward, and that it tends to be carried upward, outward and forward permitting the sustentaculum to be displaced downward and the long arch of the foot to be flattened, there is usually an oblique fracture line through the tuberosity which communicates with verticle and transverse fractures. This main transverse line extends in a more or less horizontal direction across the posterior portion of the body and tends to be opened on its mesial aspect, while the lateral surface of the bone is compressed and the tuberosity displaced outward.

#### THE FRACTURE

The typical severe fracture of the os calcis consists of a transverse fracture between the anterior and posterior processes, extending

through the anterior margin of the posterior talocalcaneal articulation. This changes the line between the contour of the tuber and the subastragaloid joint, the tuber-joint angle.

One or more longitudinal fractures of the os calcis take place, the outer taking place at the outer aspect, extending forward to the cuboid, the inner fracture extending through the inner portion, extending forward to involve the sustentaculum tali.

The cortex being brittle and thin and the inner bone being cancellous, the explosive force of the fracture results in a fragmentation of the cortex, sections being rotated and driven into the cancellous portion.

The posterior process is forced laterally and forward to produce a widening of the bone and a foreshortening. The displaced cortical fragments prevent a restoration of the anatomic contour, either by traction or by lateral compression.

The anterior spicule of the lateral fragment produces the prominence beneath the external malleolus, and this is persistent even after the strongest traction by pins through the posterior process and the tibia. However, the greatest deformity can be seen on the medial aspect, and it is here that the rotation of fragments prevents reduction by closed methods.

Anatomic restoration can be obtained by open reduction through a medial carved incision, exposing the fracture. Through this incision the fragments can be replaced and the posterior process adjusted to the anterior. The fragments tend to stay reduced, but are more firmly held by one oblique screw and one longitudinal screw.

The larger vessels and nerves behind the medial malleolus are far enough anterior to remain undisturbed, the plantar nerves and arteries are also anterior to the field of operation.

The complicated attachment of ligaments, the fine balance of the articular surfaces to carry the stress of the body weight in various positions, the proximity of synovial tunnels to transmit tendons, and the strength of the bone depending on an intact cortical structure, all explain the prolonged or total disability which result from only minor anatomic disarrangement.

#### EVOLUTION OF THE TREATMENT

The ancients made little effort to reduce fractures of the os calcis merely applying a sup-

porting bandage. In fact, very little progress was made until in 1916 Frederick Cotton suggested treatment by manipulation and impaction (Fig. 1) by pounding on lateral surface with a mallet, the foot then being placed in plaster. By 1926, Harding had devised a pressure clamp and exerted pressure on the under-

Krenz presented a method of skeletal traction to aid in reduction, the method having been worked out with Stader. The external fixation was continued after reduction was obtained.

By 1944, Gereld G. Gill reported the use of three pins inserted with the use of the Bell table.

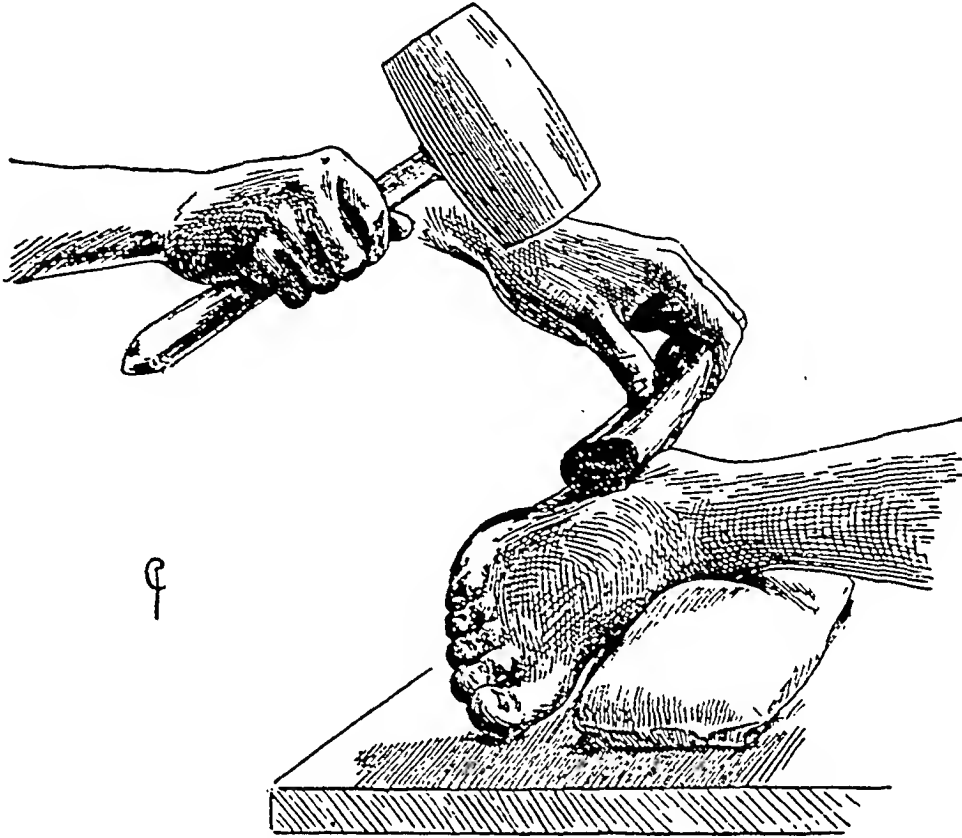


FIG. 1. Treatment by impaction (Frederick J. Cotton, M.D., 1916).

surface with a wedge. In 1927, Phillip D. Wilson discussed the value of subastragaloid arthrodesis. Robert Funsten, in 1932, described the use of a bar over the os calcis to exert traction, and, in 1934, C. R. G. Forrester offered a subcutaneous tenotomy of the tendo achilles, the use of his pressure clamp and manual molding.

The year 1937 saw the clamp of C. W. Goff designed to produce forceful manipulation, and, in 1939, Paul F. Olsen reported the insertion of Steinman pins through the tibia and os calcis, traction being exerted by means of a turnbuckle.

Two years later, in 1939, Rudolph S. Reich discussed the importance of the tuber-angle and advocated the use of a nail inserted through the skin to permit manipulation.

In 1942, J. O. Dieterley reported the use of a modified Böhler frame to permit of skeletal traction, and, in 1943, C. M. Shaar and F. P.

Thus, the proposal of a new method of treatment almost yearly reflects the difficulty encountered in obtaining good results.

#### OPERATION

Although the most remote portions of the human body have been entered by the surgeon, and in spite of the serious disability resulting from fractures of the os calcis, and the difficulty of closed reduction, except for reconstructive surgery in the later stages, or a disabling arthrodesis, and in spite of its accessibility, probably for fear of infection and osteomyelitis, immediate open reduction to obtain reposition has not been attempted.

The operative treatment here described has revealed that in the severely comminuted fracture, due to interposition of brittle cortical fragments and due to impaction, closed reduction is impossible. Open reduction has also made possible direct manipulation of the



FIG. 2. Fracture of os calcis with minimal displacement, March 7, 1946.



FIG. 3. Same fracture as in Figure 2 on May 22, 1946, with widening of os calcis and disability.



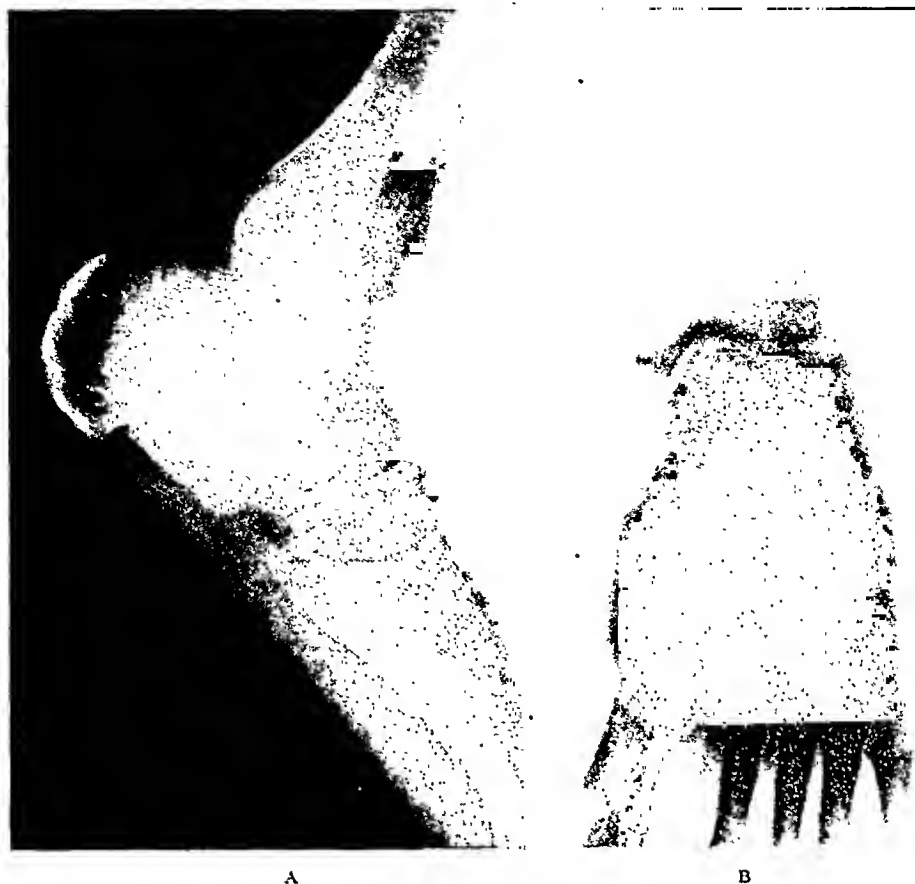


FIG. 4. A, fracture of os calcis, January, 1946.

tuberosity, the perfect alignment of the fragments and a leveling of the articular surface of the subastragaloid joint. It has been found that this joint will accommodate a small amount of displacement, without disability, and operation reduces the joint irregularity well within the limits of function.

The operation is best performed after twenty-four hours of skin preparation before the formation of blebs, or not later than ten days after injury.

An esmarch rubber bandage is applied from the toes to above the knee over the sterile dressing, the proximal end of the bandage being used as a tourniquet. Thus a bloodless operative field results which permits of good vision.

The anesthetic used is either spinal or continuous intravenous. A curved medial incision is used, medial because it is here that the interposition of fragments occurs, and only on the inner side can the displacement of the articular surface of the subastragaloid joint be seen. The abductor hallucis muscle may be avulsed with a fragment of bone at its attachment to the medial and posterior aspect of the tuberosity, in which case it and the quadratus plantae are



FIG. 4.B, x-ray of the os calcis at the time of the fracture revealing a typical lateral displacement of the tuberosity and interposition of the corticle fragment.

turned down to expose the medial surface of the bone revealing the fracture, otherwise it is retracted to the plantar surface. Good exposure can be obtained without disturbing the vessels and nerves posterior to the internal malleolus. The rotated and interposed fragment of cor-



FIG. 5. Postoperative reduction with screw retention, February 24, 1946.

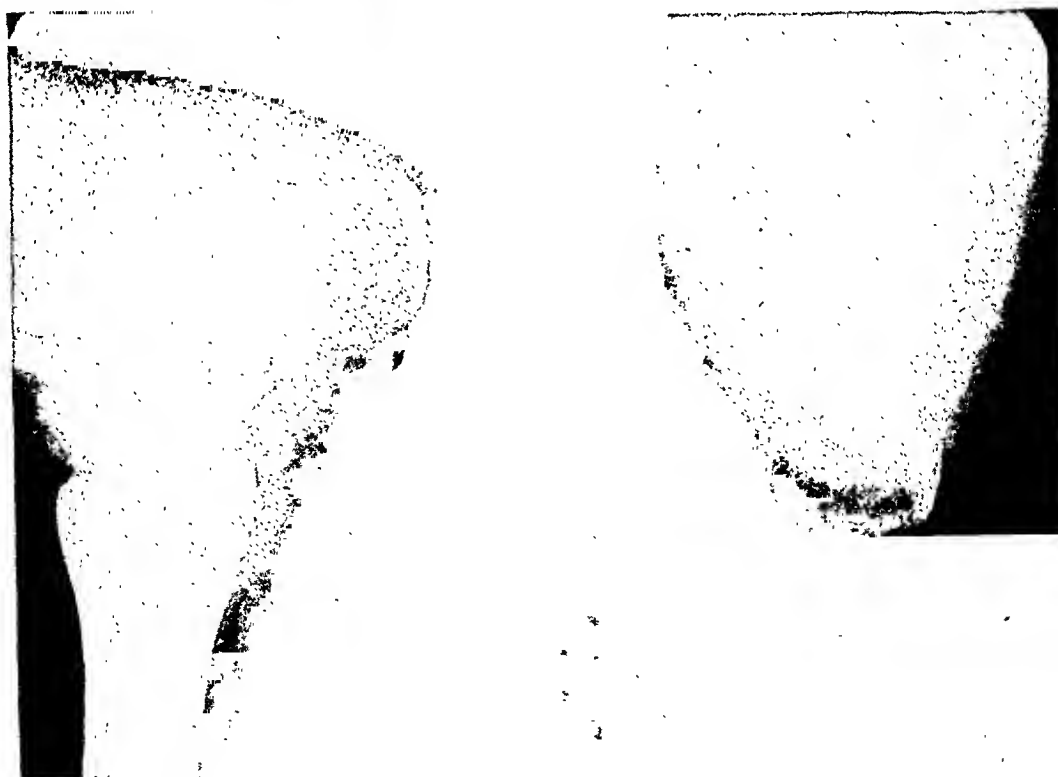


FIG. 6. Fracture following reduction and screw retention, April 8, 1946.

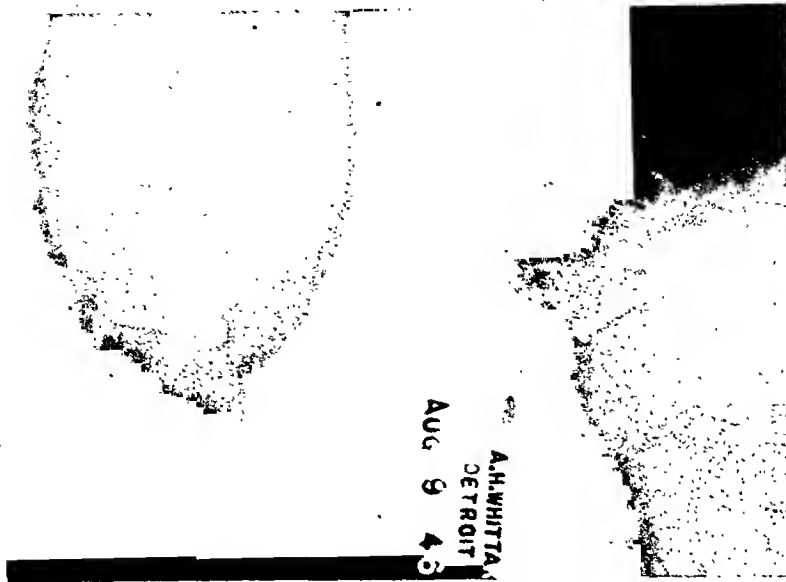


FIG. 7. Fracture, August 9, 1946.

tical bone is removed, and by grasping the tuberosity with bone-holding forceps the impaction is broken up, the fragments reduced and the tuber-angle restored.

Before releasing the forceps, drill holes are made across the lines of fracture and screws inserted which hold well. The abductor hallucis muscle and its avulsed fragment at the point of attachment are replaced and held by a screw or by sutures; the soft tissues which have been turned down under the tuberosity are replaced and closed by a deep layer of chromic catgut and the skin closed by a continuous silk suture.

A plaster mold is then applied to protect the os calcis and the tourniquet removed, no ligatures having been inserted.

#### END RESULTS

By the operation described, it has been possible to obtain anatomic reposition, and healing has progressed at a normal rate. The first patient operated upon, who had a severely comminuted fracture with marked displacement and extensive involvement of the subastragoid joint, was walking well at four months and at the end of a year presents complete recovery with no disability.

Two more patients recently operated upon are walking, have excellent anatomic reposition and will probably have as good a functional result.

Not sufficient time has elapsed to determine if, in later years, a traumatic arthritis may develop, but the smooth joint surface would tend to minimize this complication.

#### CONCLUSIONS

General anatomic and etiologic factors have been discussed, the evolution of treatment, the pathology of fractures of the os calcis, and an operation described by which good anatomic reposition can be obtained, and thus the conclusion of the syllogism presented, that "in fractures of the os calcis good function cannot be obtained" has been disproved.

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#### DISCUSSION

GROVER C. PENBERTHY (Detroit, Mich.): Dr. Whittaker, in this presentation, has provided us with something to think about from the standpoint of approaching a fracture which we all know is disabling.

He has referred to the disability as being shortened and, naturally, with the disability shortened, the period of morbidity has been shortened. In our past experience with fractures of the os calcis, we know that the disability has been long and, with the conservative forms of therapy, it has been very discouraging. Surgery, either by the subastragalar arthrodesis or the triple arthrodesis, has had much to offer.

Dr. Whittaker's series is small but it is apparent from the presentation that he is convinced, after the work that he has done in the anatomic laboratory, that this procedure has merit. The photography of the operation was excellent.

I am just wondering, during the period that the operation was going on, how much attention was paid to the subastragalar joint, and that is a question, I am sure, in the minds of many: How can the subastragalar joint be so reformed or molded in such a way as not to produce a disability even after this internal fixation?

Removal of the small particles sounds very logical because, after all, such small particles of the os calcis might be a barrier to union or early union.

There are many questions that I am sure are in the minds of many, and I think Dr. Whittaker has presented this means of therapy to be, in a way, provocative of discussion, and with the result that Dr. Whittaker was able to show in that movie, I think he is to be congratulated on his courage, his ideas and his rational thinking, and it would be interesting to see, as his series increases, what the end results will be.

HOMER STUYKER (Kalamazoo, Mich.): I think this has been presented very interestingly and very graphically.

I, like many of you, have gone through the gamut and have treated these in many different ways and have had fairly good results and bad results with each method. I have come to think that the results were more dependent on the intrinsic factors, largely the relation between the astragalus and the fragments of the os calcis rather than to the particular method of treatment.

I recall, when I first started to practice, I treated several with the Böhler method and was quite enthusiastic about it because the anatomic results were good by x-ray, though some of them did not have too good results clinically. Then a man came in about five or six weeks after an injury. He had had no treatment and was trying to walk on his foot with crutches. I thought how sorrowful it is that he did not get to me immediately after his injury. But I hesitated to go in that long afterward. We left him alone and did nothing. I see him occasionally on the street. He has a little flatness of the foot but says he has no pain and has no disability. And, as the years roll by, I think how lucky he was that he did not get to me before that time had elapsed.

I think it has been the experience of all of you that any fracture which goes into a joint which is weight-bearing, the fragments must be accurately replaced; if there is a variance greater than the width of the cartilage, the cartilage wears away on the side that is highest and gradually a traumatic arthritis develops.

I think that in these cases, the most difficult problem is to evaluate the nature of the internal fragmentation. If there are enough large fragments so they can be replaced and held by screws, I think this offers a solution, perhaps, to some of these cases. I think perhaps in others, in which they are smashed so badly that you cannot get a good re-

placement of the upper cartilaginous surface of the os calcis—fusion may still have to be the answer.

NICHOLAS J. GIANNISTRAS (Cincinnati, Ohio): I would like to ask Dr. Whittaker one or two questions.

First, he mentioned that he used the medial approach to these os calcis cases, and I was wondering why he preferred the medial approach in preference to the lateral approach.

The other question is, in these os calces that are comminuted and the tuber-angle is completely obliterated, just how do you manage to realign such a fracture, which is undoubtedly badly comminuted and the articular surface is probably partially destroyed?

The third question is, what do you do as far as the piling up of bone that you see so frequently under the astragalus when you have a fractured os calcis that gives you a thick foot, or is that overcome by the open reduction?

PAUL B. MAGNUSON (Chicago, Ill.): Of course, now that I have become a bureaucrat, I have degenerated into one of the old dodos that I used to see when I was Dr. Whittaker's age and wondered how they got that way.

I have been struggling for thirty-five years with fractures of the os calcis and I am always glad to hear a new way of approaching them. It sort of pats my ego on the back because I realize that nobody has solved the problem of the fracture which I thought I had solved some thirty years ago.

I think we should go back to the fundamentals of the occurrence of this fracture. One of them is that the os calcis, or the outer two-thirds of it, lies lateral to the medial axis of the foot. Formerly these fractures always occurred as the result of a fall from a height landing on the foot. But in the Navy, it was found that the deck came up and drove them upward, which amounted to the same thing. Once in discussing a Navy program I made the mistake of referring to the deck as the floor, and was promptly corrected by Dr. Hook.

Dr. Whittaker has spoken about the widening of the heel. I do not think it makes a bit of difference what shape the os calcis is. I think it is the displacement of the fragment, the injury to the joint and the pressure mentioned by Dr. Stryker caused by the large knob of callus under the astragalus and the posterior of the external malleolus. Now, if we are going to reduce these things, I do not think it is so necessary to reduce them anatomically because I really do not think that the shape of the os calcis has very much bearing on the matter. I think the pressure on the lateral side of the foot, the pronation of the foot because of the upward and outward displacement of the posterior two-thirds of the os calcis, the flattening of the arch which puts excess strain on the plantar fascia and the support of the foot, and the breaking into the joint are the important things.

Those fractures into the joint, I think, have a substantial part in the answer to the pain. The mechanical displacement of the heel with a consequent pronation of the foot is second.

I have severed the tendon and got more beautiful results with that and the molding than anything else, but the trouble is, when you sever the tendon, the calf muscles never come back to their adequate strength and size. But so far as replacing the fragments of the os calcis is concerned, it is absolutely ideal.

The Roger Anderson business always gave me a laugh because you put a pin through a fragment, where the os calcis may be broken into a dozen (and probably is) fragments, so it is just foolish to drill a hole through one fragment when all the rest of them are just as badly out of place as that one. If there were one solid fragment and the os calcis fractured through the neck and you could put a pin through the posterior fragment, you could probably hold traction against the upward pull of the muscles and get a good result, but that kind of fracture does not give you very much trouble anyhow, and they are very few and far between.

Phil Wilson advocated for a number of years—I have not heard him advocate it for the last twenty, I think—doing a subastragalar arthrodesis on all of them, and if I remember correctly, I said I thought they gave very good results because when you do a subastragalar arthrodesis on them, you usually replace the os calcis, move it over on the foot where it belongs, after it has been displaced; and an ankylosed joint is a painless joint. It interferes with the patient's walking on rough ground but does not give him any pain and he gets along very comfortably with it.

If there is anything that I have not tried in fractures of the os calcis, I do not know what it is, except Dr. Whittaker's method, and now that I am a bureaucrat, I do not suppose I will ever have a chance to try that. But it all goes to prove that we struggle and struggle to make something out of nothing. We come up with methods; we have a few good results, and we become enthusiastic, until we begin to get enough bad results to convince ourselves that we were not very right when we started. But if we fail to continue to try by every means in our power to make something out of nothing, then we cease to be good progressive doctors. I think this method that Dr. Whittaker has offered may be applicable in a certain number of cases carefully chosen. There is no one method that works in all of them and all the methods do not work in some of them.

ALFRED H. WHITTAKER (closing): I appreciate the kindness of the discussers very much.

Dr. Penberthy asked about the reformation of the subastragaloid joint and what attention was given to that. As I mentioned, the ligamentous structures are displaced when the sustentaculum is

depressed, and it gives a view into the joint surface which is not obtainable with the lateral approach to the subastragaloid joint; and by manipulation with a bone forceps, it is possible to get a very smooth subastragaloid joint. In these cases today, I would like to stress that I am talking about the severely comminuted, the really bad fracture that gives trouble, not the one we do not have to do anything for.

Dr. Stryker and Dr. Magnuson both stressed the importance of the fact that they should be selected cases, and I appreciate that. It is, of course, not every fracture of the os calcis that should receive the type of treatment we are dealing with here today, but I do believe that the more severe the fracture, the worse the displacement, the greater the possibilities of reduction under direct observation.

Dr. Giannestras asked about the medial approach. To explain that, all of our approaches to this fracture in the past have been through the lateral surface, and we have been doing that in order to do something about the spicule of bone on the lateral surface, about which so much callus formation takes place and which really encroaches on the subastragaloid joint at times and produces a certain part of the disability at least; we have forgotten that on the medial surface is where there is even more marked displacement, the tuberosity having been driven up, and the fragmentation of the cortex turning these fragments in between the two larger fragments in the medial surface. Our medial approach permits us to do the one thing that allows a reduction, and that is the removal of the interposing fragment which is blocking reduction and in all three cases that we have done, that has been there as an absolute mechanical blocking to reduction.

Dr. Giannestras also asked about what method we used in correcting disturbance in the tuber-angle. Well, if you noticed in the film, you could see that the manipulation with the bone forceps elevated the sustentaculum, made a smooth surface of

the subastragaloid joint and corrected anatomically the disturbance in the tuber-angle. I have never been able to do that by closed reduction. We have been able to do it each time by having the bone fragments directly under our control.

Dr. Giannestras also asked about this piling up of the bone on the outer surface. Well, there is no piling up of bone on these, as shown by the follow-up x-rays in these cases, because we have reduced that spicule which sticks out so far in the ordinary fracture of the os calcis. That spicule is not sticking out there to result in piling up of callus on the outer side of the os calcis. Therefore, we do not have that widening of the bone to deal with in our trying to get a functional result later on.

Dr. Magnuson mentioned the position of the fragments and the flattening of the arch, which is a problem, of course, we are trying to solve here. Personally, I believe that being able to get a good anatomic position does correct the disturbance in weight-bearing, does correct the thickening of the bone, and the only importance of the thickening of the bone is that that thickening is due to a piling up of the callus below the external malleolus and also due to the impaction of the fragments, which we break up and get a full-length os calcis instead of these foreshortened bones which are wide and which in themselves block mobility.

Therefore, I believe that the reposition of these fragments anatomically is of tremendous importance if we are going to get a good anatomic result.

We, too, have carried out arthrodesis over the years, and I believe that in an active man who has to make a living, who has to get about all day long in his daily work, when we do a subastragaloid arthrodesis, we are taking at least part of his ability to function well away from him, and while there are undoubtedly cases, especially old cases, in which that is the final solution and it does do away with the painful joint, it still contributes so much disability to an active man, especially in the middle years of his life, that if we can avoid an arthrodesis, I think we should do so, by all means.



# THE USE OF INTERNAL FIXATION IN COMPOUND FRACTURES\*

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COMPOUND fractures can be plated. Whether they should be so treated is still a matter for debate. Many arguments for and against have been heard, especially during the war years, and it seemed wise

With this purpose in mind an analysis has been made of the compound fractures of the shafts of femur and tibia treated on the Fracture Service of the Columbia-Presbyterian Medical Center for the years 1932 through 1942

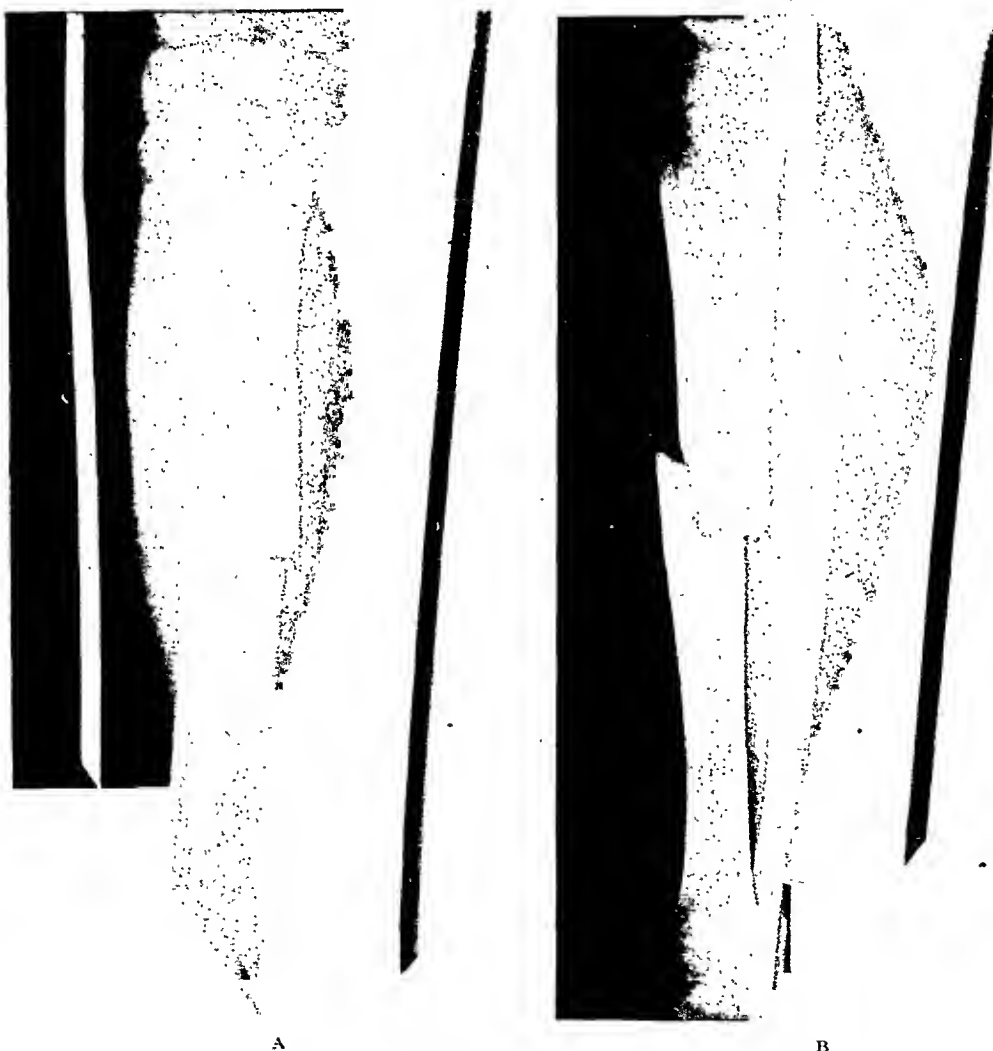


FIG. 1. A and B, original injury, compound fracture.

to see if impressions could be substantiated by facts or if a revision of these impressions was necessary.

inclusive. As there is no ambulance service for the hospital the number of such cases from 1932 through 1941 is small. In 1942, a study of com-

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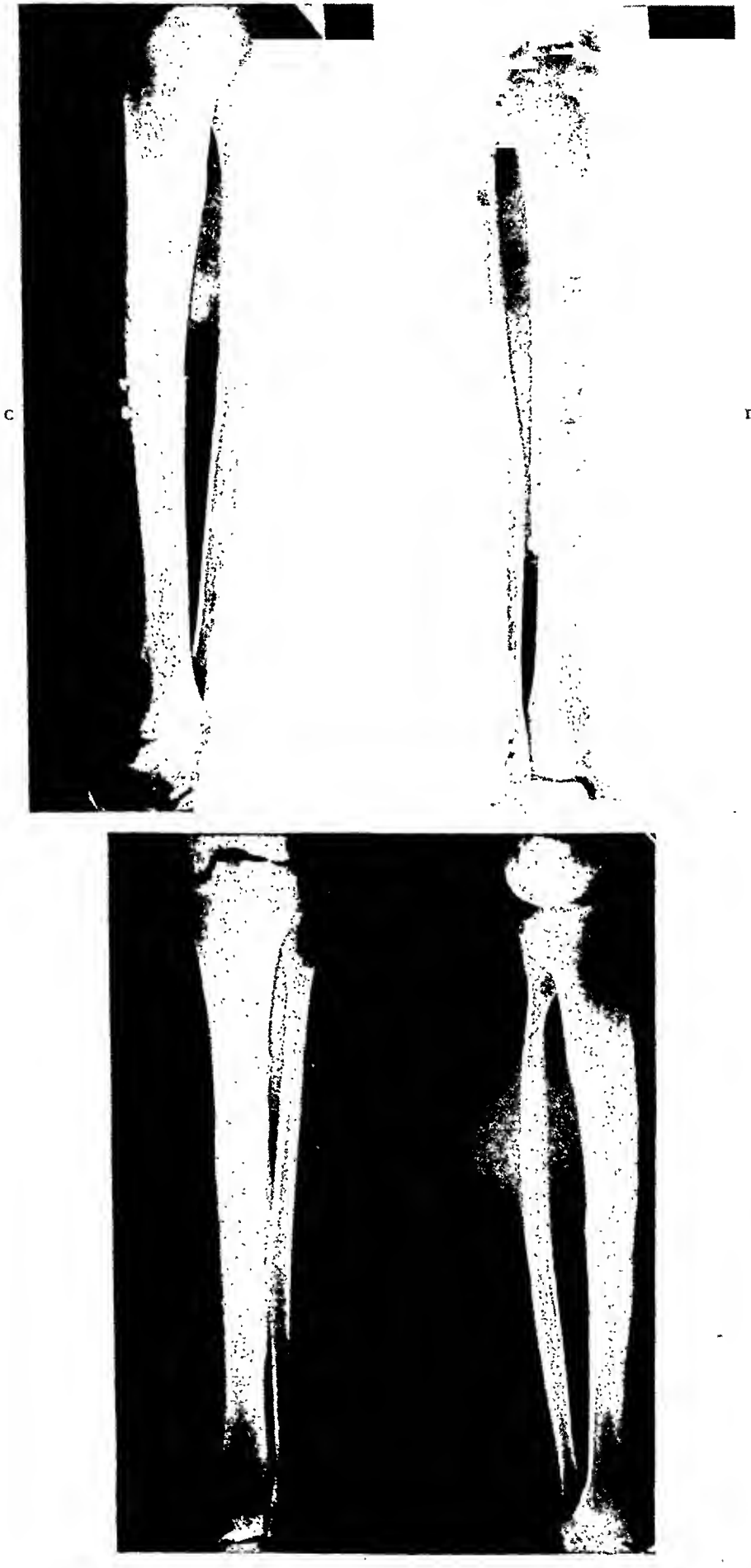


FIG. 1. C and D, post-plating; note transfixion screws; E, result.



A



B



C

FIG. 2. A and B, original injury, both fractures compound; c, post-plating.



D  
FIG. 2. D, result; all wounds healed with full function.

pound fractures was made for the Sub-Committee on Surgical Infections of the National Research Council and cases were brought from all over the city, hence the larger number treated. (Table 1.)

What is the rationale underlying the use of metal plates and screws for fixation of a compound fracture? If the bone ends are rigidly fixed, further damage to the surrounding soft parts is eliminated. Without rigid fixation any slight motion of the jagged fracture will tear tissue and cause further bleeding which, although minute in amount, may be sufficient to lower the local tissue resistance and provide a suitable medium for bacterial growth. This is not theory. The writer has seen infected compound fractures in which the systemic reaction and the drainage dropped to a minimum as soon as the slight amount of movement at the fracture site was eliminated by a plate. In one such case the patient, who had been running a septic temperature and had no appetite because of pain, announced as soon as he had recovered from the anesthesia "the pain has gone—when can I eat?" His subsequent course

was entirely uneventful except for the pre-existing and easily controlled local osteomyelitis.

Rigid internal fixation also reduces the necessity of worrying about subsequent deformity. (Fig. 1.) Normal length and axes are maintained without the need for readjustment of apparatus or plaster. There have been no cases of non-union in this series in which the fixation was rigid.

Is the method safe? That is the first question to be answered in evaluating a method of treatment. During the period under review there were no deaths in any way attributable to the use of internal fixation. There was one case of spreading infection necessitating amputation. This case will be discussed in detail later. There were minor disasters (Table 1) like broken plates and refractures but none that jeopardized life or limb. It is justifiable, therefore, to consider the method worthy of further analysis.

One of the principal arguments against the use of internal fixation is that it introduces or promotes infection. There are enough recorded cases of infection following plating to make this

no idle criticism. But the metal, if properly sterilized, does not in itself introduce bacteria nor does it provide a medium for their growth. If, however, it is improperly applied so that motion occurs and erosion of bone around the screws takes place, bacteria will multiply in the areas of necrosis so formed. The result is at best a low grade localized osteomyelitis, at worst a spreading infection. But the fault lies not with the metal but with the surgeon. It took us a long time to learn that an adequate length of plate and one or more transfixion screws to stop torsion strain were necessary and the two non-unions were a result of our ignorance. Transfixion screws were not used in our series until late in 1938. The amount of metal used, if rigidly applied with even distribution of strain upon the screws, does not increase nor predispose to infection. (Fig. 2.)

TABLE I  
TOTAL COMPOUND FRACTURES—FEMUR AND TIBIA—65  
1932-41—30 Deaths—4 Children not included—6  
1942—35 Deaths—3 Children not included—2  
1932-41 Cases analysed—20  
Internal fixation—16  
1942 Cases analysed—30  
Internal fixation—21  
Pin fixation—9

Disasters.....	1932-41		1942	
	Internal Fixa- tion	None	Internal Fixa- tion	None
Amputations.....	1	1	1	1
Non-union.....	2	0	0	0
Broken plates.....	2	0	0	0
Refractures.....	2	0	2	0
Sequestrectomy.....	5	1	6	2
	1932-41		1942	
Hardware removed....	15		15	

Rigidity is, therefore, the first principle underlying the use of internal fixation in compound fractures. Plates of adequate length, screws through both cortices placed at right angles to the plate and inserted through drill holes of the correct diameter, and transfixion screws across the fracture line, all are essential features of fixation. If there is loss of bone

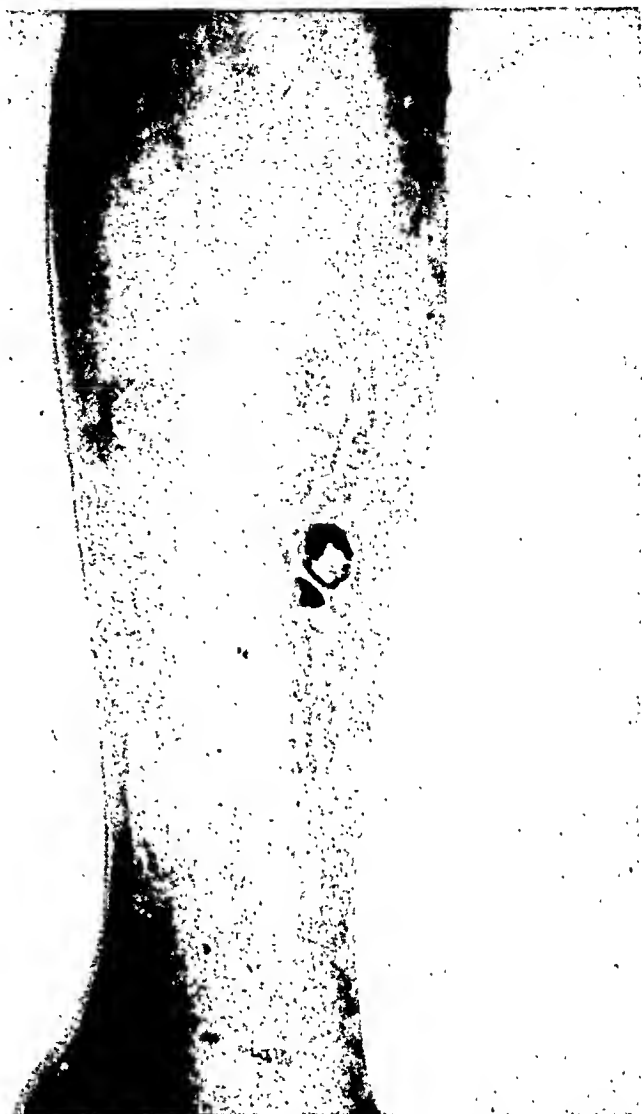


FIG. 3. Compound wound healed except for small area showing exposed plate; no infection.

substance or marked comminution, other methods of treatment of the fracture should be seriously considered.

If rigidity has been obtained, the need for external splinting has been reduced to a minimum and maintenance of function of the adjacent joints can be accomplished with the concomittant improvement of circulation and muscle action. Wound healing in these cases is much more rapid than if circulatory stasis and edema persist.

The initial treatment of the compound wound in all the cases analysed was essentially the same. Surgical débridement and copious lavage with water or saline was done in each case. Separate instruments were used for the plating and gloves and gowns were changed. From 1932 through 1941 all wounds were left open with sutures placed but not tied. Most of them were packed with vaseline gauze. The

sutures were tied, usually without anesthetic, in from four to ten days, in no case completely closing the skin edges. Healing was uniformly slow, pinch grafts being necessary in a majority of the cases. In the 1942 series, because of the nature of the study, some of the wounds were closed initially. The results are tabulated in Table II. Where rigid fixation was not obtained and where plaster encasement were required, the healing was delayed.

TABLE II  
WOUND HEALING—1942  
INITIAL CLOSURE  
Internal Fixation

1 (O) healed at 21 days
1 (S) healed at 21 days
1 (S) healed at 25 days
1 (O) healed at 9 days, broke down 7 weeks
1 (O) healed at 8½ months
1 (S) healed at 9 months
1 (S) not healed 3 years
Pins
1 (S) healed 2½ months
1 (S) healed 3 months
1 (S) healed 3½ months
1 (S) healed 4 months
1 (S) healed 4½ months

O = No chemotherapy

S = Sulfanilamide in wound and orally

In a number of cases the wounds, though not clinically infected, did not heal completely until the hardware was removed. (Fig. 3.) Because of the position of the compound wound plates and screws were placed on the bone surface presenting to avoid excess exposure. Such plates are used as temporary splints and removal after the fracture has united is not considered a failure of the method.

Chemotherapy in the light of present experience is not discussed because it was not used. Undoubtedly penicillin and other antibiotics make the surgeon sleep better at night but replace neither careful surgery nor mechanical principles.

The case mentioned earlier in which amputation was necessary had an undébrided and undrained area of damaged tissue in the posterior compartment of the leg and had the fascial layers sutured over the plate. Five days later the wound was widely opened and the necrotic muscle excised. Gas-forming organisms were found in the excised tissues. In spite of wide excision the mixed infection was not controlled and amputation was performed six weeks later. This result was due to inadequate débridement and tight closure. The presence of

the metal did not jeopardize the management of the infection but actually made it easier.

The follow-up results of five years or more are shown in Table III.

In order to include some of the experience gained in the war the writer (thanks to the courtesy of colleagues in Great Britain) has been able to obtain late results on fourteen war injuries of femur and tibia that had some form of internal fixation. The operations were per-

TABLE III  
RESULTS  
1932-1942

	Internal Fixation	None
4-4-4	10	1
3-4-4	9	1
4-3-4	2	1
3-3-4	9	4
3-3-3	..	1
Death due to other causes.....	2	
Amputations.....	2	1
Lost.....	2	4

In recording follow-up figures the findings are listed according to anatomic, functional and economic results: 4 = 100%, 3 = 75 to 99%.

formed at intervals varying from three days to six weeks after wounding, usually through a separate incision. All wounds were left open for five days then sutured under an anesthetic. There were no deaths, no amputations, no spreading infections and no non-unions. Of the nine compound fractured femurs four were still in the army in 1947. The other five were employed at full time jobs but two had limited knee motion. These two had been in plaster spicas for some months. All wounds were solidly healed. The five men with compound fractures of the tibia were all employed but two had limitation of knee motion. Four of the fourteen had received systemic penicillin but almost all had had calcium penicillin sulfathiazole powder in the wounds.

Although these figures are too small to warrant sweeping generalizations, after analysis of the cases used for this paper the writer is of the firm conviction that certain compound fractures of the lower extremity should be plated. The criteria essential for satisfactory results are correct surgical treatment of the

wound which should include no initial skin closure but adequate suture under anesthetic at five days and rigid mechanical fixation of the fracture.

In conclusion, the impressions gathered over the past eighteen years have been strengthened by this study. Compound fractures of the shafts of femur and tibia, suitably selected and properly plated, are best treated by internal fixation.

#### DISCUSSION

HENRY C. MARBLE (Boston, Mass.): I want to say that I consider this a privilege and an honor. This is the first paper that has ever been presented to this Society by a lady member and this is the first lady member.

I read her paper and I was reminded then only of the first time that this matter was proposed in my surgical experience. Dr. O'Neill Sherman, of Pittsburgh, gave a paper not unlike this before a part of the American College of Surgeons, and I believe it was in Montreal. Dr. Sherman finished his paper and the audience arose almost to a man and what happened to Dr. Sherman was very much like what happened to the merchant of Venice. They tore his raiment, they spit on his garline, and when he was through, with one or two notable exceptions, poor Dr. Sherman's paper was torn to bits.

Two or three decades have brought about a wondrous change, and now Dr. Stimson comes and reiterates what Dr. Sherman then said and we sit here quietly and blandly in our seats and agree.

Of course, one cannot but agree with what she has said. There are several factors which we have learned in these years. The first factor is how to do a proper, careful, accurate débridement. I might add that Dr. Stimson did not tell you but she probably does it—namely, that portions of the débrided tissue may to advantage be put into test tubes and subjected to the bacteriologist's wiles to see if they are benign or if they are malignant.

It is a great comfort to have the bacteriologist tell you the day after you have sewn up such a fracture that as far as he can see, there are no clostridial organisms and not too many streptococci in the wound, although parenthetically I have had gas-forming organisms in wounds in which there was no clinical evidence whatsoever. However, that is good for peace of mind.

We have also added to our armamentarium certain other drugs which Dr. Stimson says make her sleep better. Peace of mind for a surgeon is a grand thing. Off the record, sulfa drugs do not give me peace of mind, and giving all of my patients penicillin does not help my peace of mind either. I firmly believe that a careful, thorough, painstaking

débridement, carefully controlled by bacteriologic test, will give you all the peace of mind you need. If the bacteriologist shows you that there are organisms in there that require attention, then we have the sulfa drugs and we also have penicillin. Added to that, we then must fix the fracture, as she has told you, and we must close the wound.

I want to add that in closing the tibial wounds, which I think are difficult, the old expedient, which Dr. Fred Cotton taught me, of making lateral incisions far to the side of the leg so that the tibial wound over the plate can be completely closed, is useful and helpful and these lateral incisions can then or later be closed by skin graft.

OSCAR P. HAMPTON, JR. (St. Louis, Mo.): It is a privilege to discuss Dr. Stimson's paper. It was my privilege to see some of her excellent work in Italy. When the American Army turned down Major Barbara Stimson, with all of her knowledge of bone and joint surgery, it was a British gain, because she certainly contributed a great deal to the management of soldiers of the British Army who were bone and joint casualties.

I might say that, without disrespect to our British allies, she certainly rocked them on their heels in the early days because she wanted to put metal on bone in compound fractures. That was heresy. When she came to North Africa but after she had moved to Italy and carried on there, others of the British Medical Corps were doing it, too. She carried her point and her concepts were well received when she was through.

Of course, the use of hardware in compound fractures really requires consideration in two phases. Relatively speaking, its use in fractures soon after injury has been accepted. I say "relatively speaking." There are still some who do not or would not use it, but there are many others who always or frequently do.

I would like to point out that in her use of the metal in compound battle fractures, Dr. Stimson was placing this metal in compound wounds several days, perhaps several weeks, after wounding. I know that she thought the ideal time was five days after wounding, but the majority of the internal fixation were done from five to ten days after wounding. I believe we can draw an analogy to comparable fractures seen in civilian life. We receive them from distant places or we may have them under our care from the beginning. Unreduced fractures with open wounds, five to ten days after injury—that is the problem.

Now, Dr. Stimson stated it frankly, that the problem of the use of metal presents itself in this way: Does it produce infection? I would like to present again for your consideration the concept that wound sepsis results from the septic decomposition of dead tissue, including blood clot in dead space. Particularly is this true in the presence of an effective antibacterial agent to protect living

tissue from invasive infection of organisms recognized as still present in the retained devitalized tissue and in the open wound; so that if a wound can be rid of devitalized tissue by a meticulous débridement, of which Dr. Marble spoke, and the surgery is good enough to put on the metal without creating additional devitalized tissue and to eliminate residual dead space, how is the metal going to predispose to sepsis. It does not if this concept is accepted.

I would like to speak briefly about the use of metal in septic wounds. Often, the rigid internal fixation of a fracture may be an important factor in overcoming a septic compound fracture.

A septic compound fracture presents two problems: one, control of sepsis and wound healing; the other, maintenance of reduction of the fracture projected toward healing in as near an anatomic position as possible.

Now, if one accepts the concept which I outlined, the use of metal is not going to prolong that sepsis

and, as Dr. Stimson said, by holding the fragments still, continuing trauma and subsequent devitalized tissue is minimized. I also would like to point out that dead space about the unreduced fracture is eliminated.

BARBARA B. STIMSON (closing): I want to thank the discussers for their courteous handling of the paper.

I agree entirely with Dr. Marble that skin closure is essential as soon as it is safe. We found that in five days, most of the very bad wounds could be closed with not much tension. We have used the lateral releasing incisions with a great deal of interest and help, because I agree with him that it is essential to cover the tibia, if possible.

Of course, I agree with Dr. Hampton. We have seen a number of septic compound fractures that progressed very satisfactorily with the use of internal fixation. We have plated them at a month and a month and a half, in the presence of pus, and the bones unite and the sepsis is controlled.





## SURPLUS PARTS OF THE SKELETON\*

### A RECOMMENDATION FOR THE EXCISION OF CERTAIN PORTIONS AS A MEANS OF SHORTENING THE PERIOD OF DISABILITY FOLLOWING TRAUMA

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THE author wishes to present the thesis that certain parts of the skeleton, including both bone and cartilage, are unnecessary for the reasonably normal functioning of that part of the body to which they belong; I wish, however, to make it clear that the recommendations for bone sacrifice which are made herewith are to be applied only in the presence of those lesions which experience has proved are difficult to treat by more conservative measures. I am particularly anxious not to be misunderstood in the matter since, although I believe that certain fractures are better treated by resection of parts, I am not in favor of removal of bone unless there is an indication therefor.

As proof, I believe, that there has been for many years a general agreement on the part of surgeons that certain portions of the skeleton, if cartilage be included in this classification, are better removed than attempts made to promote healing; the menisci in the knee joint may be used as examples. With reference to these fibrocartilages, more especially the medial, it has long been proved, I believe, that they are surplus in that they are not necessary to the proper functioning of the joint, and that when damaged it is advisable to excise the cartilage which is the site of injury. Furthermore, it may be expected that slight or no disability will result from such removal. There has been general agreement, also, that the coccyx in the human being is not very useful and that its resection may be indicated when, as the result of fracture and malunion, disability is suffered by the patient.

In this contribution it is suggested that there are other individual parts of the skeleton that are of minimal importance, and that not only may time be saved in return of the individual to duty but that in many instances the end result of excision may be better than that which follows the employment of complicated procedures, many of which are difficult to perform

and which are of necessity followed by long periods of disability in order that healing may take place. It is also true, I believe, that in many instances delay in removal of damaged parts may result in secondary changes which are irreversible.

It is not the intention of the author to claim priority for any of the procedures discussed or recommended. It would appear to be true, however, that the philosophy which underlies the thesis, which is suggested herewith, has not previously been presented. Although a few references have been included I believe that no useful purpose would be served by an attempt to prepare a bibliography or to trace the originators of any individual procedure. Since in fact the growth of surgical art has been gradual and all writers have either purposefully or unknowingly taken advantage of the contributions made by their predecessors, I make no apology for failure to give adequate credit.

Among those parts of the skeleton which are, in the author's experience and opinion, relatively unnecessary, the following are listed for consideration. As the matter is discussed in the following pages, it will be noted that the indications for excision are more positive in some instances than in others: (1) clavicle, (2) acromion process, (3) head of the humerus, (4) lateral condyle of humerus—capitellum, (5) median epicondyle of humerus, (6) olecranon, (7) head of the radius, (8) distal fifth of the ulna, (9) carpal scaphoid, (10) carpal semilunar, (11) menisci of the knee joint, (12) head of the fibula, (13) patella, (14) rib cartilages, (15) ribs and (16) coccyx.

*Clavicle.* In 1941, the author published an article upon the subject of complete dislocation of the outer end of the clavicle. In this article the recommendation was made, that in cases of complete dissociation of the lateral end of the clavicle from the acromion, a lesion which is accompanied by rupture of all or nearly all the ligaments taking part in the acromioclavicular

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FIG. 1A

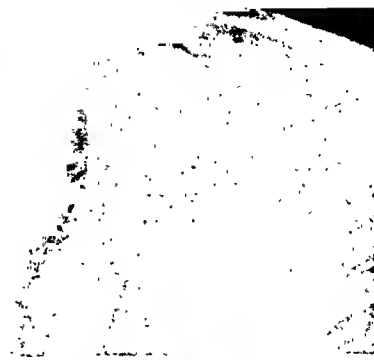


FIG. 1B



FIG. 1C



FIG. 1D

joint, the treatment of choice consists in the resection of the lateral third of the clavicle. A similar recommendation is made with reference to fractures of the outer third of the bone, a lesion which may be considered a variant of the former. Although dislocation of the sternoclavicular joint is not followed by any serious loss of function, the disfigurement may be important. It is recommended, therefore, in the treatment of this lesion that the medial third, or half, of the clavicle be excised.

In the contribution referred to attention was drawn to the fact that the clavicle may be removed *in toto* without any disability and with but minimal deformity arising therefrom; also, that the removal of the outer third of the clavicle in the treatment of the lesion referred to results in a strong shoulder without any dis-

ability, and that the total period of loss of time which follows operation is short. Since the clavicle is practically useless to the human frame, and since occasional though unusual cases of non-union are seen, resection of the whole bone is, in the author's opinion, preferable to the exhibition of procedures designed to promote union in such cases. As Copland has suggested, resection of the whole clavicle may be indicated in a rare case of fracture of the middle third of the bone with extensive comminution.

Since the publication of the above article several contributions have appeared in the literature which support the author's contention. Among these are those of Mumford, Copland and Elkin.

*Acromion Process.* Fracture of the acromion

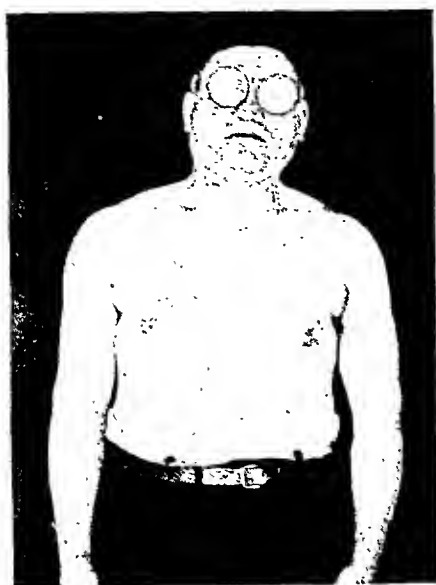


FIG. 1E



FIG. 1F



FIG. 1G

FIG. 1. A to G, Case C. N., show acromion process completely removed together with (accidentally) tip of clavicle. Seven photographs indicate site of incision and show that there is minimal loss of function and atrophy.

is an unusual injury nor does it, as a rule, require any considerable length of time for union to take place. Nevertheless, although the procedure is not urged unduly, the suggestion is brought forward that in certain cases, at least, of fracture of the acromion process excision of the distal fragment is followed by no demonstrable loss of function, and that the length of time required before return to full duty may be shortened by the employment of such a procedure.

In a limited number of cases of subacromial bursitis (frozen shoulder) accompanied by extensive involvement of the bursa more room is made available to carry out whatever interference may be necessary if the so-called sabre cut over the top of the shoulder be used. If this incision be employed, that part of the process which is separated from its base should be resected. Not only does such a procedure avoid delay of healing, since more space is made avail-

able for the affected bursa, but more complete and more prompt return of function may be expected.

In the majority of cases demonstrating lesions of the cuff or of calcium deposition in the floor of the bursa such a radical incision is not required; in the selected case, however, such as that indicated above, the sabre cut is valuable.

If the acromion process is resected, it should be done in such a way that sufficient tendinous and periosteal tissue is conserved to make it possible to suture the muscle bundles to one another. If this be done, the function of the shoulder joint is but little disturbed.

CASE 1. No. 8772-46. C. N., fifty-eight years of age, a stoker, was first seen on December 18, 1946. He had been totally disabled on account of extreme pain and loss of function of the right shoulder for a period of three months during which time physiotherapy, including x-ray therapy, had been employed. X-ray examination showed the presence of

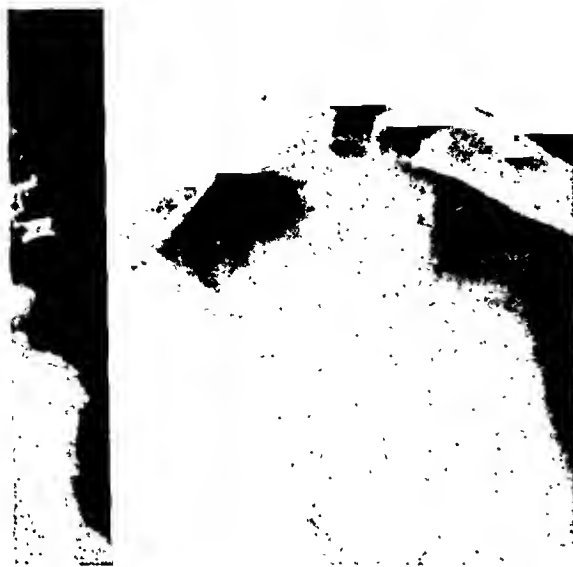


FIG. 2. A, McKim's case. Displaced head of the humerus is barely visible several inches away from the glenoid.

a radio opaque substance in the subacromial bursa, though not in the usual site.

Operation was performed on December 20th. An incision was carried over the top of the shoulder. The lateral portion of the trapezius and the deltoid muscle was separated from the acromion process in such a way that a small portion of periosteum was left attached to the muscles. The acromion process and, accidentally, a small portion of the distal extremity of the clavicle was resected. Bethune shears were employed for this purpose. The roof of the bursa was thus completely exposed. It was found to be greatly thickened and, as suspected, the calcium deposition was in the roof. The whole of the roof of the bursa was resected. The bursa itself was found to be almost completely obliterated by adhesions between the superficial and deep portions. All tendons attached to the cuff were found to be intact and no interference in the floor of the bursa was carried out. The wound was closed with fine black silk sutures and the patient returned to bed with the wrist attached to the crossbar and the head of the bed raised. This position was maintained for five days, after which he was allowed out of bed and the wrist reattached to the head of the bed overnight for an additional five days.

The accompanying photographs show that four months after operation movements were substantially complete in all directions, were free from pain and that little or no muscle atrophy had occurred. (Fig. 1.)

*Head of the Humerus.* In elderly people fractures through the anatomic neck of the humerus are rather common injuries. In such cases there is usually complete or almost com-

plete separation of the proximal fragment from its blood supply. Furthermore, there is often marked displacement of the head. In the author's experience no matter what form of treatment is carried out in this older group of persons, usually women, it is more or less impossible to obtain a perfect result I believe, however, that as a rule the most satisfactory end result is obtained by early removal of the head.

Although the case referred to herewith, and for which I am indebted to Dr. L. H. McKim, is exceptional in so far as the displacement of the head was concerned, the fact that a reasonably good shoulder followed resection is at least suggestive:

CASE II. Mrs. A. J. S., sixty-five years of age, fell down the stairs on April 24, 1936. X-ray showed fracture of the surgical neck of the left humerus with marked comminution and very marked displacement of the head. At operation the head was found in the substance of the left breast. The displacement had apparently taken place by the head following down the posterior surface and the lower edge of the pectoralis major muscle. The arm was placed in a Thomas splint with abduction and elevation of the arm. This position was maintained for about one week after which the patient was allowed to get up.

The patient was examined one year later; she had, in the meantime been doing all her housework and had an excellent functional arm. At that time the grip of the left hand was one-half that of the right. She was seen again in 1940 four years after the injury. Her statement at that time was that she could do everything except put her hand behind her head. She was reexamined on May 21, 1947, eleven years after injury. The patient is now seventy-six years of age. The movements at the shoulder are good with the exception that she cannot elevate the humerus to more than 90 degrees as compared with 140 degrees on the right side. The grip of the left hand is now two-thirds that of the right. (Fig. 2.)

When operating upon the more usual case the author wishes to caution the surgeon who is not very familiar with the anatomy in the inferior part of the shoulder joint region. This caution applies particularly to the risk of damage to the circumflex nerve as it descends through the quadrilateral space and to the main trunk of the musculospiral as it curves around the scapular head of the triceps. It is wise, I believe, to cut through the tendinous attachment of at least the lower part of the pectoralis major muscle to the humerus and so obtain a clear view of the axillary structures and of the

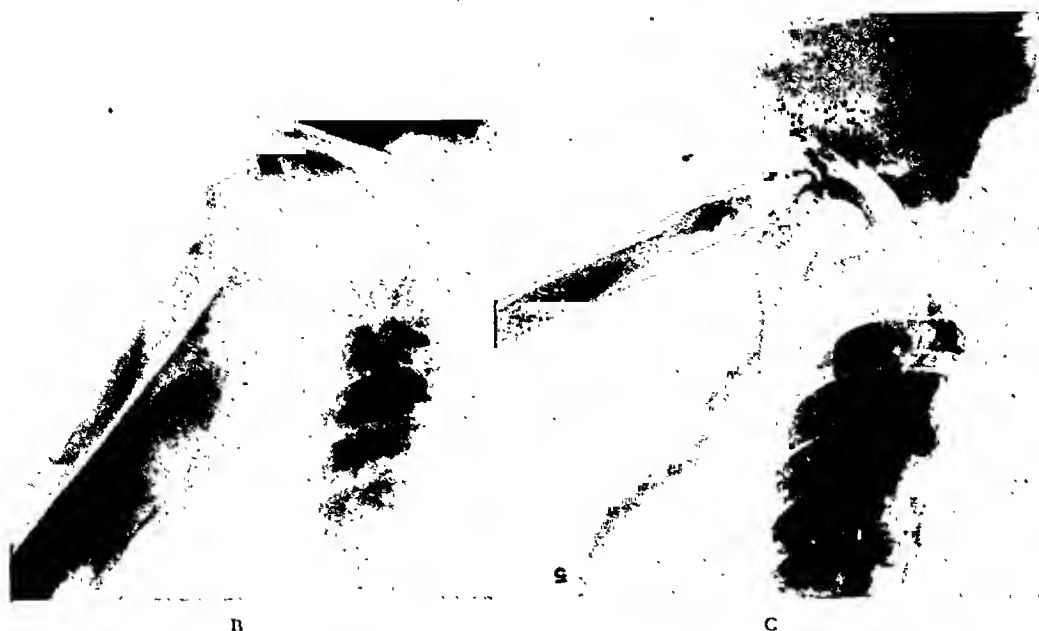


FIG. 2. B and C, x-rays illustrate movement at the shoulder four years after injury.

lower part of the capsule. The head will commonly be found protruding from a rent in the capsule. This explains in large measure the difficulty that there is in many cases in closed replacement. As indicated above, it is the musculospiral nerve which runs the greatest risk of damage. This nerve should, therefore, be clearly identified and protected during the operative manipulations required for removal of the head of the bone.

*Lateral Condyle of Humerus—Capitellum.* Fracture of the lateral condyle of the humerus to which is attached the capitellum (Fig. 3), that is to say that portion of the lower end of the humerus which is in contact with the head of the radius, although it is not a very common injury in adults, does nevertheless occur in an occasional case. Reduction of the displaced bone fragment and maintenance of position is somewhat difficult, consequently, in many clinics it has been the practice to carry out open reduction and to fix the fragment in position by means of screws or nails.

Since as a matter of fact the entire articulation of the forearm with the humerus is through the ulna and the trochlear surface of the humerus, it is evident, I believe, that it is not necessary that the upper end of the radius come in contact with any bony surface. It is recommended, therefore, that in the event of fracture of the lateral condyle of the humerus in the adult, the separated bone fragment be removed. If this be done, there is no necessity for fixation during the period of repair, and function may be started almost immediately.

It should be made clear that this procedure is not recommended in children. Resection of the lateral condyle has been carried out in a sufficient number of cases in the adult to prove that time is saved, a simple operative technic is employed and no appreciable deformity nor loss of function results.

A curved incision, convexity forward, over the anterolateral border of the arm is used to expose the loose fragment; a partially subperiosteal resection of the bone is accomplished with as little damage to the tendinous attachments of the extensors as possible. Preliminary identification of the musculospiral nerve and its branches is recommended.

*Humerus—Medial Epicondyle.* Since in a fairly large proportion of cases of separation of the median epicondyle of the humerus the detached bone fragment cannot be replaced without operation, and since it is likely to interfere with joint function and jeopardize the ulnar nerve, there is, I believe, a general agreement that in such cases it is wise to remove the fragment.

*Olecranon.* In general, there is every reason for repair of the usual transverse fracture of the olecranon; there are, however, cases of direct injury with fragmentation in which excision of bone fragments would appear to be indicated. When this is done, very careful suture of the triceps fascia is imperative. As stated in the opening paragraph of this contribution, the procedure is adopted as the lesser of two evils and is one which is usually forced upon the surgeon by the circumstances of the case.



In those cases in which the fracture is more impressive, whether this be as the result of gross comminution or in consequence of the separation of an individual fragment from the head, resection of the head and neck of the radius is strongly recommended.\* A long and somewhat extensive experience in removal of the head of the radius has made it clear that this part of the anatomy is surplus; I would urge, however, that when arthrotomy of the elbow joint in consequence of fracture of the head of the radius is carried out, it is unwise to simply remove a loose fragment or fragments, nor will the result be satisfactory if the neck of the bone is not also removed. The upper part of the radius, therefore, should be divided close to the bicipital tubercle without, however, encroaching upon the latter.

Dislocation of the head of the radius in the adult is usually associated with fracture at about the junction of the middle and upper third of the ulna—Monteggia fracture. In such cases it is recommended that union of the ulna be permitted to take place before the displaced head of the radius is interfered with. It is not within the scope of this contribution to discuss the treatment of fractures of the ulna; as is well known, however, this is not always an easy matter. Our experience has been that the insertion of a Kirschner wire through the olecranon and so through the medullary cavity of the bone is the most effective form of treatment.

Arthrotomy of the elbow joint for the purpose of resection of the upper end of the radius has been recommended through different incisions. The author would like to recommend for this purpose an incision on the anterolateral border of the joint. A curved incision, convexity forward, on the anterolateral border of the elbow joint about 7 cm. in length, is made through the skin and superficial fascia. This is carried down to the deep fascia which is incised slightly more laterally; the trunk of the musculospiral (radial) nerve in the lower part of the arm is then identified and gently retracted together with its branches. If this be done, damage to this important structure is avoided.

The capsule of the joint slightly anterior to and below the lateral epicondyle is thus somewhat widely exposed. It is entered by plunging blunt-pointed scissors of the Mayo type into the joint. The appearance of synovial fluid in

the wound is proof that the joint has been entered. The capsule is torn open by spreading the scissors and an adequate arthrotomy thus established. The capitellum is identified and the fractured head of the radius clearly exposed. Sufficient room is made available so that the whole of the neck of the bone is seen. It is wise, I believe, to remove a cuff of periosteum distal to the line of division of the bone so that reformation of spicules will be less likely to occur. I have been accustomed to divide the neck close to the tubercle of the biceps, using for this purpose rib shears of the Bethune type; as a rule, two bites are required to divide the bone completely which is then carefully smoothed off, using either the same instrument or a sharp rongeur. Usually few or no ligatures are required. The synovia and capsule are sutured, as best may be, either with very fine black silk or very fine chromic catgut.

*Ulna—Distal Extremity.* Whereas the ulna forms the entire articulation of the forearm with the humerus, it is equally true that the radius alone is required in order to articulate with the carpus, and so the hand. In other words, whereas the head of the radius is an unnecessary part of the anatomy, the distal fifth of the ulna is equally unnecessary. Dr. William Darrach, I believe, first (1913) recommended removal of the distal end of the ulna in the treatment of unreduced cases of Colles' fracture with deformity and shortening of the radius. Following the first stage of the War, that is from the autumn of 1918 until the summer of 1925, during which time the author was in charge of the Surgical Service at Ste. Annes Military Hospital, many cases of non-union of fracture of the lower end of the ulna were admitted. It was found that by removal of the bone, or by resection of a portion thereof, practically perfect function was obtained. (Fig. 5.)

Since 1925, in civilian practice, the number of cases which have been seen of either non-union in the lower fifth of the ulna or in which shortening of the radius has been followed by disability consequent upon the relatively long ulna has not been large. A sufficient number of patients have, however, been operated upon to confirm the opinion that the ultimate fifth of the ulna is surplus. It is recommended, therefore, that in the event of non-union of the lower end of the ulna either the distal extremity should be removed or a segment of bone resected so that the bone ends will not come in

\* Needless to say that if a loose fragment of the capitellum be found in the joint, it should be removed.





FIG. 4A

contact with one another. In the treatment of valgus deformity at the wrist joint, whether due to an unreduced Colles' fracture or premature fusion of the radial epiphysis, excision of the lower ulna to above the inferior radioulnar articulation should be carried out.

**Scaphoid (Navicular).** For many years there has been much discussion regarding the advisability, or otherwise, of removing the fractured scaphoid from the carpus. The author does not wish to suggest that its removal is the procedure of choice. Although I believe that it is true that twenty years ago fracture of this bone frequently resulted in non-union, such is not the case today. In this connection I quote, at some length, from the contribution on the subject by L. H. McKim who says, in part, as follows. As the result of the treatment of 125 fractures among soldiers and air men, he states, "All cases were treated by plaster fixation. The average period of fixation for acute cases was 9 or 10 weeks. Union was frequently good after 6 weeks. Some old cases were fixed for 8 months. Position of fixation is very important. Joints do not tend to become stiff when fixed in a functional position."

"The position of maximum function of the wrist is best demonstrated by the following procedure:

1. Clench the fist and note the following:
  - a. Degree of dorsiflexion of the wrist.
  - b. Degree of ulnar deviation of the hand.
  - c. Position of opposition of the thumb to the fingers.
2. Extend the phalanges of the thumb and note that: The metacarpal bone of the thumb is now in direct line with the shaft of the radius.

3. Now extend the fingers at the metacarpophalangeal joints.
4. Apply the plaster case in this position with careful observance of the above points. The terminal phalanx of the thumb and the metacarpophalangeal joints of all the fingers must be free"

None of the fractures in McKim's series failed to unite. He further states that he has never seen non-union in a case of fracture of the scaphoid that has been adequately treated from the time of injury.

Despite improvement in the treatment of fracture of the scaphoid by a better understanding of both the position of the hand during fixation and the absolute necessity for preventing all movement of the carpus during the period of healing, there still remain a certain number of cases of non-union. In such cases a very disabling arthritis is very likely to occur if the lesion is not corrected. In such cases, moreover, delay in operative treatment (removal of bone or successful bone graft) results in a very serious disability unless arthrodesis is carried out.

In the foregoing paragraphs the author has, I believe, made clear that he does not recommend removal of the carpal scaphoid in all cases, or even in a large proportion of cases, of fracture; on the other hand, he wishes to present the argument that early removal of both fragments is not followed by any considerable disability. It is, therefore, in my opinion, reasonable to suggest that time is saved, the risk of ultimate seriously disabling arthritis is avoided and, since the function of the wrist joint following removal of the bone is but little interfered with, there is little or no objection to excision, particularly in fractures associated with any considerable displacement.

The operation for removal of the carpal scaphoid is not easy. It is difficult to obtain wide exposure without damage to essential structures; I believe, therefore, that a short outline of the technic, which in the author's experience has proved most satisfactory, is not out of place.

With a sand pillow beneath the ulnar border of the carpus and with the hand in mid-pronation, a curved incision with convexity toward the dorsal surface approximately 8 or 9 cm. in length with its center opposite the styloid of the radius is made. This incision is carried down through the thin skin, the small amount of subcutaneous fatty tissue and the flap turned back-



FIG. 4. A to C. x-ray and photographs illustrating appearance of upper end of the radius and almost complete function of the elbow joint and rotary movements fourteen years after resection. Note especially the site at which, in the author's opinion, division of the bone should be made.



FIG. 5A

ward. This exposes the fascia on which is seen the branch of the radial nerve and beneath which are the tendons to the thumb. The small radial nerve is displaced along with the extensor tendons to the fingers and to the wrist, as well as the long extensor to the thumb, and the tendons on the radial border of the snuff-box displaced toward the radial side. If this is done gently, it is possible to uncover a substantial portion of the capsule of the radiocarpal joint. The proximity of the radial artery must, of course, be borne in mind. Through the exposed capsule is plunged the points of scissors of the Mayo type. When the synovial fluid appears and it is clear that the joint has been opened, the points of the scissors are spread sufficiently to tear an opening into the joint to permit reasonably adequate exploration.

The author is of the opinion that it is advisable to remove both fragments when a decision has been arrived at to remove either one. Careful exploration of the joint should be made with a view to discovering the fracture line in the bone. If this is done, one can be certain that the bone which is to be removed is, in fact, the scaphoid. If the fracture line is not identified, it is difficult to be sure that the bone which is grasped is the one that has been damaged.\*

\* That it is difficult to differentiate between the bones in the carpus is illustrated by the recommendation to place a skin clip on the bone before removal and prove its nature by x-ray examination (Campbell).

The late Dr. Frederick J. Tees recommended the use of dental forceps as a means of holding and fixing the bones in the carpus while their attachment is being divided. The use of such instruments is to be recommended.

Experience in a number of cases in which the scaphoid had been removed through the incision referred to and a dislocated semilunar removed at the same time through an anterior incision, suggests that it is perhaps wise to remove both semilunar and the scaphoid when indications are present for the removal of the latter. In this event both bones are, of course, removed through the posterolateral incision. Not infrequently damage to the lower end of the radius complicates fracture of the scaphoid or dislocation of the semilunar bone. In such cases, I believe, early removal of one or both bones is more imperative. (Fig. 6.)

Although perhaps not quite apropos with regard to the present contribution, the fact that not infrequently fractures of the carpal scaphoid are complicated by injury to the lower end of the radius must always be borne in mind. In such cases, the possibility of obtaining a thoroughly good result from treatment is problematical; in general, however, I believe that this complication is an added reason for operative removal of the fractured scaphoid.

*Dislocation of the Semilunar (Lunate).* Since the author's opinions with reference to complete dislocation of the semilunar bone are crystallized, an extensive discussion of this subject will not be included. I believe that it is inadvisable to attempt closed reduction of the dislocated semilunar since, on the one hand, considerable damage may result in attempts at reduction and, on the other hand, the risk of aseptic necrosis is great. If the carpal semilunar be removed soon after injury, the disability which ensues is minimal and the patient is able to return to work after a shorter period of convalescence than if even a successful attempt at reduction has been possible.

Removal of the dislocated bone is a simple procedure. A curved incision on the volar surface of the carpus surrounding the prominence made by the dislocated bone exposes the median nerve and the long flexor tendons. These are gently retracted and, when the bone is grasped, a few snips of the scissors suffices to separate it from its remaining attachments. A ten-day period of fixation in plaster with the wrist and hand in the position of rest should



FIG. 5. A to C, photographs and x-rays, small boy who suffered compound separation of radial epiphysis at twelve years of age. Four years later marked valgus deformity treated by resection of distal portion of ulna, x-ray appearance of wrist twelve years later at which time only slight disability existed.

be followed by a similar period of active movement.

*Head of the Fibula.* Although with the change in the level of front bumpers on automobiles fractures of the head of the fibula have become less frequent, such injuries do, however, occasionally occur. Without laboring the thesis the author wishes to recommend that in such cases a subperiosteal resection of the head of the bone is easily carried out, is followed by no disability and the length of time required before the patient can return to full duty is determined only by the period required for healing of the soft tissues. That the fibula, except for its lower fifth or quarter, is not very valuable is proved by the willingness exhibited by surgeons to use this bone for bone grafting purposes.

*Patella.* Since resection of the patella has been discussed in the literature at such length since Brooke's original article, I shall not discuss this subject in any detail here. Although I am of the opinion that, if possible, the patella should be conserved at least in cases of transverse fracture, frequent experience on the part of many surgeons has proved that this bone is not absolutely necessary in order that function of the lower extremity may be adequate. In the event, therefore, of comminution which renders accurate replacement of fragments difficult or impossible, it may be advisable to remove the bone and to re-establish the extensor mechanism of the knee joint from the soft tissues.

*Costal Cartilages.* It is of interest that there is little reference in the literature of trauma to fracture of the lower rib cartilages. This rather common injury appears to have been overlooked by most authors. In the recently published work by Bancroft and Murray on "The Motor-Skeletal System" the article by Harrison L. McLaughlin, entitled "Injuries to Ribs, Costal Cartilages, Sternum and Sternoclavicular Joint," although the title of the chapter includes the "Costal Cartilages," the text as a matter of fact makes no reference to them.

Although contusion of the anterior portion of the lower chest wall is not as a rule a serious matter and disability does not persist for any considerable length of time, when either the cartilages are separated from the rib ends, or from one another, or themselves fractured, an annoying disability is experienced by the victim in that the broken ends are likely to slip over one another with changes of position, this slip being accompanied by a sharp pain.

As is well known, cartilage repairs itself inadequately and slowly; it is, therefore, recommended that in the event of fracture of the rib cartilages below the fourth, or separation from the bone ends, a length of 2 cm. more or less from each end be excised. The operation is, of course, a simple matter, carried out under local anesthesia, and is followed by complete relief and complete healing within a few days.

Removal of a costal cartilage above and including the fourth is to be avoided since a soft

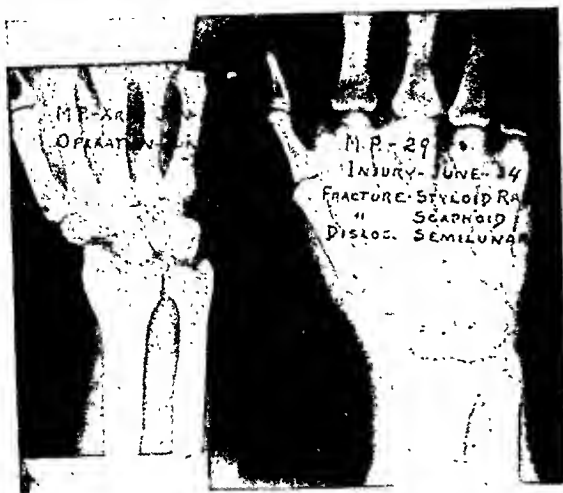


FIG. 6. X-ray photographs of wrist in which dislocation of the semi-lunar, fracture of the scaphoid and of the radial styloid was treated by resection of the two carpal bones. This man recently examined showed slight disability only.

spot is produced which is annoying, on the one hand, and may result in a hernia of the lung in the upper part of the chest and may expose the heart to damage. Since injury to the cartilages above the fifth is practically unknown, the above memorandum is not of much importance to the surgeon interested in trauma.

**Ribs.** Although rib resection as a sequel to trauma will rarely be indicated, for the sake of completeness in the development of the thesis submitted in this essay certain comments are made herewith. Since hundreds of ribs are removed in all clinics interested in the treatment of pulmonary tuberculosis, and since comparatively little disability usually results from such resection, it may be said that these bones are of no great importance to human physiology. In this connection may I submit the thesis that, although the ribs are of some importance in the respiratory effort, their chief functions in addition to their protective capacity in so far as the thoracic viscera are concerned are the maintenance of the spine in the erect position and as a *point d'appui* for the powerful muscles attached to them.

That one or more ribs may be sacrificed, in whole or in part, in order that thoracotomy for intrathoracic operations may be performed is recognized by all surgeons as a harmless procedure. In cases of scoliosis consequent upon chronic pleural or pulmonary disease correction of the deformity may be accomplished by resection of bone (rib) segments. In cases of chronic pleural disease, whether consequent upon an

organized hemothorax or chronic empyema, a scoliosis with convexity away from the affected side is almost inevitable. In the performance of thoracoplasty for pulmonary tuberculosis, a scoliosis with the convexity toward the affected side is certain. If, therefore, in the case of scoliosis consequent upon chronic disease the patient is submitted to rib resection, it is possible to bring about correction of the pre-existing curvature.

In the foregoing pages the author has discussed the problems presented by injury to a selected sixteen parts of the skeleton. It is clear that other parts may, upon occasion, necessitate resection. In this connection perhaps the most important one is the astragalus (talus) regarding which the only comment I would like to make at the present time is that, although astragalectomy may sometimes be an absolute necessity, particularly in cases of compound injuries with consequent contamination or infection, it is advisable, as a rule, to attempt to conserve this bone in the foot.

Among infrequent lesions, those of the sesamoid bones, is either hand or foot, may be damaged and may require removal. In such cases, their removal is not accompanied by any considerable disability. In the uncommon injury or avulsion of the anterior superior spine in young men, it is perhaps true that, if the bone fragment be removed and the tendinous structures attached to it sutured to the pelvic bone, a more rapid return of function is obtained.

In the event of fracture through the neck of the mandible resection of the condyle is a proper procedure; if, however, a pseudarthrosis is induced by adequate movement during the healing period, such operative interference is unnecessary.

Recent work by Dr. John Gerrie and his associates in the treatment of decubitus ulcers over the trochanters of the femora and over the tuberosities of the ischia in paraplegics has been of special interest to me. They have found that more permanent healing of such lesions is obtained if the underlying bone is removed.

The spinous processes and transverse processes of the vertebrae are easily dispensed with; however, resection, on account of disability as the result of injury is not strongly recommended.

In the foregoing pages, to a limited extent, memoranda have been made with regard to

technical procedures. I do not believe that this matter should be further detailed in this contribution; I should like, however, before bringing this essay to a close to make certain observations in this regard.

In so far as possible longitudinal incisions on the extremities should be avoided. For the most part curved incisions are recommended. The value of the curved incision is two-fold: In the first place, because a flap is formed closure of the wound is likely to be obtained with less tension; it is possible, therefore, to employ finer suture material and so interference with the blood supply to the skin and fascial edges is minimized. Secondly, if a flap is formed by the use of the curved incision, the superficial wound is ultimately situated at some distance from that of the bone or joint, as the case may be. Consequently, if even a minimal infection of the surface wound does occur, spread of the infection to the deeper and more important structures is likely avoided.

Although in the performance of certain procedures, as for instance removal of a meniscus from the joint, the use of a tourniquet is of value, in general, and more particularly in the case of the upper extremity, the employment of this means of controlling hemorrhage is to be avoided. In any event, if employed, it must be applied with the greatest care.

I wish to urge the employment of compression dressings, particularly as recommended by Neal Owens and ourselves. The essential features of our compression dressing are the employment of thick cotton waste, (4 to 8 inches), and the use of bias-cut flannel bandages. The latter should be at least 6 inches in width and, in our experience, have proved to be more useful than the various elastic bandages on the market. Needless to say, they are more durable and much less expensive.

#### SUMMARY

In the foregoing pages certain memoranda have been presented regarding surplus parts of the skeleton. An attempt has been made to show that a number of bones or portions thereof and, also, cartilages are not absolutely necessary for reasonably satisfactory functioning of the part.

It has been indicated that it is not the suggestion of the author that bones be indiscriminately removed but that, under certain circumstances, less disability is suffered and

time is saved by skilful removal of damaged parts.

In this connection sixteen individual parts of the skeleton have been considered. It will be noted that, on the one hand, the indications for removal of certain parts are more positive than for others and, on the other hand, less disability follows the removal of certain structures than is the case with others.

With reference to the actual technic of excision certain memoranda have been made which, in the author's experience, have proved useful.

#### DISCUSSION

PAUL B. MAGNUSON (Chicago, Ill.): First, I would like to say that I suspect my friend, Dr. Gurd, is accumulating a bone bank up in Montreal.

I think, when he speaks of parts being unnecessary, perhaps he would like some day to modify that to less essential for life, health and future happiness; in other words, I think we have to weigh whether the patient is going to have in this particular instance a longer or shorter disability as the result of one treatment or another, and whether the result in the future is going to make him more able to do his work, whatever it may be, than he would be if he were treated by some other method. That is a question of experience and judgment and I am sure that that is the way Dr. Gurd decides on the cases in which he considers removing certain parts of the skeletal system.

In regard to the menisci, I think we are all agreed that if they are properly removed and if they must be removed, they should be removed because they are acting as a foreign body, and a foreign body in any part of the body that is causing trouble should be and can be taken out. The menisci are probably the outstanding example of removal of a part in the skeleton or attached to the skeletal system that gives no bad results at all if the diagnosis is right and the removal was for the proper purpose.

On this clavicle business, I probably have been wrong for many years because I have always understood that fractures of the clavicle and dislocations of the acromioclavicular joint came as a result of the same mechanism applied in a different way, that is, the forcing of the shoulder toward the sternum, with additional force, in the case of dislocation of the acromioclavicular joint, applied on the arm in a downward direction and rather slowly; in other words, a man being thrown obliquely and the arm dragging down as the body is projected forward in the momentum.

I have been teaching my students that the function of the clavicle is to hold the shoulder backward and upward and add to the strength in lifting, and I do not think I am going to change my mind about that. It still is a prop between the sternum and the

shoulder. Of course that prop can be shortened and one can get along, really, without a lot of parts.

If we want to find out how people can do tricks in the absence of a lot of different muscle pulls, all that is necessary is to look at some of these little infantile paralytics that have had various muscles put out of business, and yet can do things that seem to be perfectly impossible. Not long ago I saw a man in one of the Navy hospitals who had completely lost the median part of his quadriceps and that fellow can do anything with his leg that anybody else can do. How he does it, I do not know. I always thought the quadriceps was an extensor of the knee and added great power. Well, he has the median part and the lateral part of the quadriceps but the medial part, that is, the middle part, is all gone.

One can get along, we know, with fewer parts. We know very little about the reciprocity of muscles, and when these people get along as well without a part as they did before, they probably have learned tricks that we have not learned to analyze as yet. And, incidentally, Dr. Inman out at the University of California has done some perfectly remarkable work on muscle function which I hope will be published very soon in connection with this work on artificial limbs that the Army and Navy and Veterans' Administration have been engaged in for the last few years.

This use of muscles in compensating for loss of skeletal structure, I think, is a thing about which we do not know very much. The resection of the acromioclavicular joint has been done many times and it simply takes off the pressure between two parts that are sore; and I certainly would not take the clavicle out because I had a dislocation of the clavicular joint, because that nice big ligament that runs between the coracoid and clavicle is quite an essential thing; and if that is repaired, it does not make much difference whether you have a little bit of ligament running between the clavicle and the acromion or do not. It is only when that ligament is torn that the clavicle really does displace upward, or rather the shoulder downward, and when the ligament is restored, the shoulder is held up.

The head of the radius—sure, take it out. But I do not believe in taking it out so far down that you do not have any bearing surface between the radius and the ulna because that limits the power of the muscles attached thereto. The lower end of the ulna is the same way. Dr. Davis used to say that the ulna should be considered as an extension of the arm downward and is concerned with motions of strength at the elbow; the radius, an extension of the hand upward and concerned with dexterity of the hand, so you can take out the ulna, at least the lower end of it. I noticed that in this boy that Dr. Gurd showed there actually had been developed another bearing surface between the radius and the

ulna in the process of growth and he had a very nice lower radio-ulnar joint.

Now, certainly, you can move the hand with the lower end of the ulna gone, but you do not have too much strength in pronation and supination. But if you have a grip, you can use your upper arm muscles in pronation and supination.

WALTER G. STUCK (San Antonio, Texas): Of course, like Dr. Magnuson, I can agree that many of these operations are useful such as excision of the patella, excision of the olecranon, excision of the clavicle, etc. I do find it difficult, however, to go along with Dr. Gurd on all of his excisions of bone.

My most obvious objection is to removal of the coccyx. It seems to me that this has been worked over many times. We all know that the coccyx is a sort of focal point for neuroses, and I have never seen anybody who has been disabled by an injury to the coccyx who was relieved by the removal of it. That is about the same way I feel about the small sesamoids under the first metatarsal head. If the sesamoid bones are injured, I doubt very much if the symptoms are relieved by their removal.

As far as condyles of the humerus are concerned, that is, of course, an open subject. It seems sometimes that replacement of the condyle and fixation with a screw might give a better functional elbow joint than would excision of a large fragment, such as you saw in the lantern slide.

The question of pain in the costal cartilages is very interesting to me because about thirteen years ago, I wrote a paper reporting eight fractures of the sternum and made the point that fractures of the costal cartilages caused symptoms long after the bone had healed. I had never thought of the possibility of reaction of the costal cartilage but that seems to make sense.

A new development in this field is the view nowadays about removal of comminuted fractures of the patella. Strangely enough, we have learned that we can get along well without the patella. Formerly we thought that the patella was absolutely necessary to normal knee function.

As I say, I can agree with probably 88 per cent of this paper, but about the remaining 12, I want to stay open to conviction.

BOARDMAN M. BOSWORTH (Bronxville, N.Y.): I think there can be very little disagreement among us in general on Dr. Gurd's thesis. However, I am going to confine myself to the acromioclavicular joint.

It does not seem to me at all proper to remove the outer end of the clavicle for such a minor injury, which can very well be repaired in a minor fashion, and this I have tried to do in five instances. In all of those cases, you will have to take my word for it, the patients have excellent function and no complaints.



ROBERT H. KENNEDY (New York, N. Y.): It is always a pleasure to listen to Dr. Gurd and the various problems he has brought up have interested me for a considerable time.

Most of these procedures are well recognized as justifiable in certain instances, but like all things that are different, their indications are not recalled by surgeons in general as various cases arise. I think that is due to the lag in our thinking when it comes to adopting something that is a bit different from the way we have been brought up.

This presentation is particularly important because it reminds us that if a part might have to be excised at some time, the result will be much more favorable if we make up our minds on it right away and do it early rather than feeling that we are forced to do it later. This holds for adults only. We should not discuss children in this connection. I remember one unfortunate experience which I had, in which I believed I had to take out a badly comminuted head of a radius, and I always wished I had not done so.

I am coming to believe, in spite of Dr. Bosworth's pictures which we have just seen, that possibly the best result we can get in complete separation of the acromioclavicular joint is obtained by taking out the outer third of the clavicle.

With derangement of the superior radio-ulnar joint due to a fracture of the head of the radius, excision of the head and neck, extending just short of the biceps tuberosity is required. It should be done as soon as the x-ray findings show that you have a fracture which involves that joint. If it is done late, the results are often little, if any, better than without any operation at all. It is not worth doing unless you start mobilization immediately.

In the case in which there has been a failure of restoration of the inferior radio-ulnar joint following Colless' fracture, and the patient is complaining moderately, or bitterly, we too often forget that it is fairly simple to remove the distal fifth of the ulna with relief.

Dr. Gurd mentioned the scaphoid and semilunar. I have come to believe that instead of taking out the scaphoid and semilunar, it is better to go "whole hog" and take out the proximal row and be certain that the os magnum will be in contact with the radius. The wrist functions better than when part of the proximal row is left in.

In our efforts to appose the fragments in a simple transverse fracture of the patella, an irregularity of the level of the joint surface results too often. If we cannot restore the undersurface of the patella to its original position, it is more satisfactory to take out the patella with the proper suture following it. Of course, it seems to me there can be little question about the advisability of excision when one has a compound fracture or a comminuted fracture.

We all have an idea of the amount of disability

which ensues from removing the fractured parts Dr. Gurd has mentioned. We would say that it is extremely little, or it is one-third, and so forth. If we see a patient in whom, as we analyze it, it seems that we would probably get a greater disability from conservative treatment than we have seen occur in a case in which a part was removed for some reason or other, we should remove that part as early as possible and not wait until we are forced to do it. To me, that is the great lesson in this paper—the time element.

HARRISON L. McLAUGHLIN (New York, N. Y.): I am in complete agreement with the philosophy expressed by Dr. Gurd and we are indebted to him for this excellent paper.

I must admit to the absence of any mention of the costal cartilages in the article which he cited. A costal cartilage lesion sufficiently severe to warrant operative therapy has not yet been encountered on our service. I am glad to know that when such a lesion does occur symptoms can be relieved by excision and we will be on the lookout for these lesions from now on.

I would like to speak about removal of a portion of the acromion. Dr. Gurd's slide showed the excision to have been done through the acromioclavicular joint. It must be agreed that it is possible to do this with adequate resultant shoulder function, but we have found that when possible, it is advantageous to divide the acromion just lateral to the level of this joint. By so doing it is possible to remove almost as much acromion as if the excision had been done through the joint, and yet an intact bony and ligamentous girdle is left in the shoulder.

I would like to ask Dr. Gurd why the humeral head was removed in the fracture dislocation he described. Removal of the head fragment through a pectoral incision, although minimizing the risk of damage to the brachial plexus, could hardly have had an important bearing upon the resultant function of the shoulder. When possible, it would seem advisable to excise the humeral head fragment through an operative route which also exposes and makes possible a repair of the existing damage to the soft part machinery of the joint mechanism. In our experience functional results are best when this can be done.

I agree with Dr. Gurd that a partially executed removal of the clavicle does not interfere with its function as a prop. It is a disadvantage to remove the whole outer third of the bone since such a procedure separates the bone from its attachments to the coracoclavicular ligaments. The best results in our hands have followed upon an excision, the level of which was just lateral to the attachment of these ligaments. If not enough of the clavicle is removed certain patients have developed pain in the operative area on adduction of the arm.

LAURIE H. McKIM (Montreal, Canada): If I may

be permitted just a moment, in answering the last speaker. Far be it for either Dr. Gurd or myself to suggest that the pictures shown of my case with the marked displacement of the head of the humerus, is the ideal procedure. This was a woman of about sixty-eight years, with a blood pressure of about 260. She weighed about 200 pounds and was only about 5 feet 5 inches tall. She had fallen downstairs. At the time that she was brought to the hospital, she had this very marked displacement of the head of the humerus. The head was removed as a minimal procedure, hoping that she might get some use of the shoulder joint. I hope that Dr. McLaughlin does not think that is our idea of what the removal of a head should be, or how it should be done.

I may say that the head was in a huge hematoma in the middle of the substance of the breast where it had gone along the sheath of the pectoralis major muscle.

FRASER B. GURD (closing): I already indicated that it was not possible in the time at my disposal to cover the sixteen parts of the body plus the eight supplementary parts. If I have not been able to make certain points clear, I have already apologized in that regard.

It is unfortunate that Dr. Magnuson has had so little experience with cases which would allow him to learn the function or lack of function of the clavicle. The removal of the whole clavicle either for the exposure of the thoracic dome or of the brachial plexus or for purposes of operating on the subclavian, has been done sufficiently often by a number of different surgeons, including myself, to be certain that the clavicle has no function other than as a point d'appui for the muscles attached to it; and if, when the clavicle is removed, care be taken to attach the muscles which were previously fixed to the posterior or superior portion to those having their origin from the inferior border of the clavicle so that each acts as a point of fixation for the other, then there is no disability.

I have x-rays of individuals, farmers, belonging

to a family in which nine male members are without clavicles. They work with a horse-drawn plow in the spring; in the wintertime, they fell trees; in the summer, they pitch hay. The fact that the clavicle is not very useful is proved, I think, by cases of that sort.

I think it was four years ago that through the correspondence portion of "Life," which had pictures of a gentleman who had no clavicle, it was made clear that there was interest in this matter because within the next week, I received about twenty copies of "Life" from different parts of the country. It is just a matter of passing of time, I feel sure, before Dr. Magnuson will have had enough experience with the clavicle to realize the uselessness of this part of the anatomy.

In a published article seven years ago on the subject, Dr. McLaughlin, I indicated that I determined the point of division of the clavicle by slipping my finger underneath the bone and when I met the ligament, I stopped and divided the bone at that point. Among other things, this experience has proved to me that the ligaments between the coracoid and the clavicle have very rarely been torn. They are intact even in cases in which there is complete dissociation of the acromioclavicular joint.

I already indicated, gentlemen, that it would take me a long time to read everything I have written and I purposely made the matter sketchy. I have no intention, even if the Chairman would allow me to do so, to go back and cover the whole ground all over again.

I want to thank Dr. Stuck for agreeing with me 85 per cent. Very few things I have ever suggested ever got anything like that agreement! That is really, I think, perfectly marvelous.

Dr. Kennedy has always been known for his graciousness, and I appreciate his kind remarks. If he is anxious to remove more parts than I am, I will not argue with him. Quite clearly, these memoranda do not apply to children, particularly with reference to the radial head.



# FURTHER OBSERVATIONS ON PENETRATING WOUNDS OF THE HEART AND PERICARDIUM\*

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IN 1941, the above authors reported forty-seven cases of penetrating wounds of the heart and pericardium.<sup>1</sup> In that group, there were twenty-seven patients who were alive twenty minutes after admission to the accident ward and who allowed time for definite diagnosis and definitive treatment. There were seven deaths in that group with a mortality of 25.9 per cent. The group that we are presenting at the present includes an additional thirty-three cases admitted to the hospital with the diagnosis of a cardiac wound. In any southern city of any size with a high percentage of negro population, the incidence of wounds of the heart will necessarily be high. In this group of thirty-three cases there were: four white males; six colored females; one white female, and twenty-two colored males.

Injuries to the heart and intrapericardial portions of the great vessels may be caused by any sharp instrument or projectile that may enter the thoracic cage. In this series the most frequent offending articles in the order of their frequency of occurrence were: knife, pistol and ice pick. There were twenty-four knife wounds, six gunshot wounds and three ice pick wounds. It must be remembered by the staff in the accident ward that wounds of the heart and great vessels may be caused by an injury in practically any quadrant of the chest or may be reached by an injury to the upper abdomen; however, the more frequent site of injury is in the left chest from the second interspace to the seventh intercostal space within the nipple line. It must also be remembered that the heart may be reached by a relatively short knife through the mid-axillary line or from a posterior wound. The portion of the heart that is most frequently injured is the right ventricle because of its anterior position even though a large part of the ventricle is protected by the sternum. Next in frequency come the left ventricle, the auricles and the aorta in this order. (Figs. 1 and 2.)

## PATHOLOGY

Following a wound to the heart of any consequence, one of two things begin to happen. There is the immediate production of either acute cardiac tamponade or rapid exsanguination. In order for acute cardiac tamponade to occur the wound in the pericardium must be relatively small and the wound in the heart and the amount of bleeding from the heart muscle, chamber or vessel must be relatively brisk. If the amount of bleeding is such that the opening in the pericardium cannot decompress it rapidly enough, either into one of the pleural cavities or to the outside, acute cardiac tamponade with the findings of Beck's triad<sup>2</sup> will be found. In one of our cases there had been complete obliteration of the left pleural cavity due to a previous acute pleurisy. This patient had a large wound in the chest wall and a small laceration of the tip of the right ventricle. He had all of the signs of acute cardiac tamponade. He had apparently decompressed through the wound in the chest slowly but enough to prevent death from tamponade before surgery could be instituted.

If the wound in the pericardium is large and the pleural cavities are patent, relatively rapid exsanguination may occur. In the majority of the patients in this series who died before surgery could be instituted, death was due to exsanguination and most of them either had multiple wounds of the heart or single large wounds of one of the chambers of the heart with a large enough wound in the pericardium to allow free bleeding into one or both of the pleural cavities. If the wound in the chest wall is large enough fatal hemorrhage may occur to the outside. It is believed by the authors that cardiac tamponade at times will be a life saving factor, as most cases of cardiac tamponade will allow time for diagnosis and treatment. The amount of blood that is necessary

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to produce acute cardiac tamponade varies directly with the rapidity of bleeding from the heart. In the rapidly bleeding case with a very small wound in the pericardium only 200 cc. may be enough to produce a fatal tamponade. In the case in which the bleeding from the

died on his second postoperative day, secondary to what was apparently slowly progressing hemorrhage. Both pleural cavities had filled repeatedly with fluid that was an admixture of blood and serum, which was tapped repeatedly. In spite of repeated transfusions, the patient

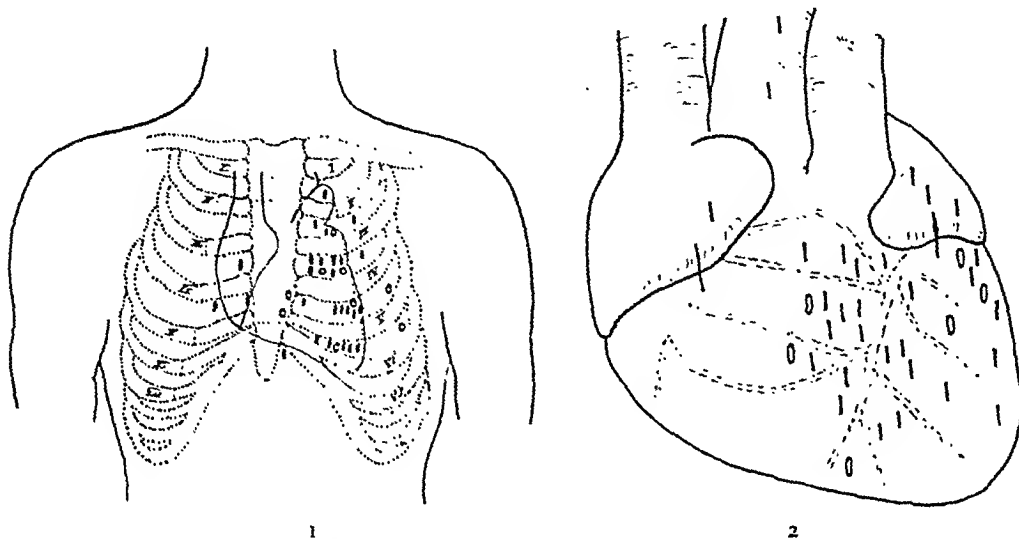


FIG. 1. Diagram showing external wounds in the chest wall.

FIG. 2. Diagram showing wounds of the heart muscle and intrapericardial portions of great vessels.

heart is relatively slow, the pericardium may be gradually stretched so that it may accommodate 400 or 500 cc. before serious compression of the heart occurs.

Cerebral emboli may occur secondary to mural thrombi that have formed at the site of the wound in the endocardium. In one case (A-2) of the present series five of the chordae tendineae had been severed in the right ventricle and there had also been perforation of the interventricular septum. There were mural thrombi at the sites of the perforations in the ventricles and the septum as well as on the stumps of the chordae. This patient died on his third postoperative day with definite evidence of cerebral embolism. There is another complication that should be mentioned here and that is continued bleeding from the heart wound even after apparent successful suture. In case (A-15) in which there were through-and-through wounds of the right and left ventricles secondary to a twenty-five caliber bullet, apparently successful suture of both wounds was carried out. At the time of closure of the chest both of the wounds were apparently dry, although the operator made the observation that there was a tremendous amount of bruising of the muscle about both wounds. This patient

died about fifty hours after surgery. Gelfoam, or some such similar substance, would have been of tremendous benefit in this case but this will be taken up later in the paper.

#### DIAGNOSIS

Diagnosis and successful institution of surgical treatment in wounds of the heart and pericardium depends on several factors. The foremost of these is the education of the house staff and more particularly the members of the team in the accident ward in quick recognition of a wound of the heart. An alert staff must remember that a wound of the heart can occur in practically any penetrating wound of the chest or the upper abdomen. In practically all cases of cardiac wounds the general condition of the patient and the presence of shock will be out of all proportion to the extent of the obvious wound. If acute tamponade is present, the classical triad of Beck<sup>2</sup> will present itself in the form of low or falling arterial pressure, high or rising venous pressure and a quiet heart. The patient will be bathed with profuse perspiration and usually will be in varying degrees of delirium. As brought out in our other series,<sup>1</sup> acute alcoholism is usually present and that in itself will occasionally

slightly confuse the clinical picture. Pulse rate is surprisingly slow unless there has been considerable hemorrhage into the pleural cavities or to the outside. If there is time for a direct measurement of the venous pressure in the antecubital space and fluoroscopy, the diagnosis may be definitely established. In acute cardiac tamponade there will be an increase in venous pressure to levels of 250 mm. or above. Fluoroscopy will show widening of the cardiac shadow and greatly diminished or absent pulsation of the pericardial shadow. When there is a large wound of the heart and an equally large laceration of the pericardium so that active and free bleeding may occur into the pleural cavities, the venous pressure will be normal or even lower than normal and the examination of the chest by fluoroscopy may show only evidence of a large amount of fluid in one or both of the pleural cavities. If this is found and it is known that the time of the injury has been within the previous several hours, exploration of the thorax is imperative. Laceration of the lung tissue as a rule does not produce massive hemorrhage in a short period of time. With one or both of the pleural cavities partially filled with blood, it must be recognized that there is active bleeding occurring which must be arrested. Fatal hemorrhage can and does occur from lacerations of the internal mammary vessels or from one or more intercostal vessels.

#### TREATMENT

Many of our cases have been sent directly from the accident ward to the operating room because of recognition of a cardiac wound by the staff without preliminary determination of venous pressure or fluoroscopy; however, it might be added here that this is the only phase of our treatment of cardiac wounds that is hurried. There is no sacrifice of aseptic surgical technic. The team which scrubs for the operation goes through the routine scrub that is customary for any elective procedure and the thorax is prepared just as carefully with adequate shaving, cleansing with green soap, saline, ether and a suitable surface antiseptic. We have rigidly standardized this procedure, even though the enthusiasm of the resident to "get into that chest" might encourage him to take some short cuts. As a direct result of this, we have had only one infected case in the past fourteen years. This patient developed infection of the skin flaps and osteomyelitis of the

end of the resected ribs. There have been no cases of pericarditis or empyema.

There is little or no premedication given as most of these patients are comatose and need no sedatives or narcotics. We have omitted narcotics from the preoperative regimen because of the depressing effect on respiration. If time allows, the patient is typed and cross-matched for transfusion on the way to the operating room. Intravenous fluids may keep the pressure of the patient up if there has been massive hemorrhage but in the presence of acute cardiac tamponade there is little if any benefit to be derived from fluids or plasma.

There is little to be said about the choice of anesthesia as most of these patients need oxygen under positive pressure at the beginning of the operation and do not need an anesthetic agent until tamponade has been released. After operation has been begun the anesthetist may begin to feed in a little nitrous oxide. We believe that cyclopropane should not be used because of the effect of the cyclopropane on the irritability of the heart. Positive pressure must be continued after opening of the pleural cavity and continued until the chest is closed.

At this point, in regard to irritability of the heart, one small technical maneuver might be mentioned. Quite frequently during manipulation or rotation of the heart, during or after sutures are placed, the rhythm of the heart will become very irregular. This irregularity is very easily controlled by the use of 1 per cent novocain sprayed over the surface of the heart. Within a space of seconds the irregular rhythm will become regular and further manipulation may be carried out.

The choice of the type of incision has undergone a gradual change at this hospital over the years. In some of the earlier cases the classical Spangaro incision was used but this was discarded for the "τ"-type incision. The cross bar of the "τ" is placed along the left side of the sternum and the lateral limb of the "τ" placed over the rib nearest the wound of entrance. In this type of incision there would be two "L"-shaped flaps dissected up which would naturally open more space for potential infection. In the past six years we have used a nearly horizontal incision placed over the rib nearest the wound of entrance. This incision has been advocated by Elkin and in our hands has been found to be most satisfactory. If there is need for more exposure, the costal cartilages

of the ribs above and below the resected rib may be cut through and more exposure may be obtained. If there has been careful examination of the wound of entrance, a definite idea of the direction of the knife, bullet or ice pick may be obtained so that through experience the place-

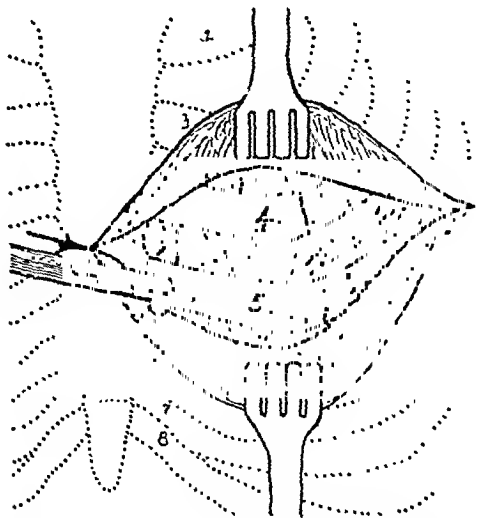


FIG. 3. Diagram giving transverse incision placed over the rib to be resected.

ment of the incision will become most adequate. The rib should be stripped from the sternum outward as shown in (Fig. 3), as stripping in this direction is easier and also quicker. If the pleura has not been damaged, an effort should be made to strip the pleura away from the pericardium; however, with the patient under positive pressure anesthesia, entering of the pleural cavity will be of little consequence. A small nick is then made in the bulging pericardium or the original wound is spread widely with the fingers. An effort to cut the pericardium with a knife or scissors may result in unnecessary injury to the underlying myocardium as it is found in many of these cases that the right ventricle will be directly beneath the pericardium. This is apparently due to the "floating" action of the blood and clots in the pericardial sac.

After opening of the pericardial sac the liquid blood is quickly aspirated into an auto-transfusion outfit. A tremendous amount of blood may be salvaged, both from the pericardial sac and the pleural cavities in this manner. In one case in this series there were 2,500 cc. given by auto-transfusion and in another there were 1,900 cc. given by auto-transfusion. The subject of auto-transfusion has been

adequately covered by Griswold and Ortners<sup>3</sup> from this institution. Free clots are scooped out by the finger tips and a search is made for the wound in the heart. If the wound is anterior, brisk bleeding and increased activity of the heart will make the wound apparent as soon as the tamponade is released. If the wound is not apparent immediately, the method advocated by Beck<sup>4</sup> should be carried out and a silk suture should be placed through the apex of the heart for traction. This suture will steady the heart while search is made. A word of caution was put into our previous report in that the traction suture must be relaxed with each contraction of the heart or the suture will cut through the heart muscle and the operator will have to deal with two lacerations of the heart muscle instead of a single one. Further traction sutures may be placed either to the right or left of the original traction suture for rotation of the heart. The heart can apparently be rotated almost 90 degrees without damaging circulation through the systemic or pulmonary systems.

When the wound of the heart is found, the tip of one or more fingers may be placed over the wound until satisfactory sutures can be placed. After one or more sutures are placed, traction or crossing of the placed sutures will control hemorrhage until all of the sutures can be secured. As we brought out before, none of the sutures should be deep enough to penetrate the endocardium because of the possibility of thrombi forming at the points of perforation of the endocardium.

To the inexperienced surgeon or staff member a wound of the auricle will frequently present quite a problem. The wall of the auricle may be so thinned out that the placement of one or more sutures will only result in two more pinpoint perforations that will bleed with each contraction of the auricle. The use of Gelfoam or some such similar substance, as advocated by Jenkins<sup>5,6</sup> may provide the answer to this problem. The substance may be tied over the bleeding points or may possibly be held over the bleeding points until adherence occurs within several minutes. In case (A-23) our resident found after placement of adequate sutures in a wound of the right ventricle that there was considerable oozing, both from the laceration and from the suture holes. A piece of Gelfoam was tied over the bleeding points with satisfactory control of the troublesome oozing.



After control of the bleeding from the laceration of the heart or great vessels a suitable opening is made from the pericardial sac into either the right or the left pleural cavity for decompression of the pericardial sac. After any manipulation of the heart there is a definite outpouring of serous fluid and this in itself is enough to cause serious embarrassment of the heart if the pericardium is closed without drainage into one of the pleural cavities. None of our cases have been drained to the outside. We believe that drainage into one of the pleural cavities is adequate for decompression of any heart wound. We have not used drainage to the outside in any of our cases because we believe that a drain to the outside invites infection from the outside into the pericardial sac. The one case in which there was obliteration of both pleural cavities there was a drain placed from the pericardial sac into the subcutaneous tissues, which was removed on the second postoperative day after a satisfactory vent had been established.

The chest wall is then closed in layers with interrupted silks under positive pressure. There is rather meticulous care taken in the closure so that there will be no problem of subcutaneous emphysema or subcutaneous collection of fluid.

Postoperatively, all these patients are placed in an oxygen tent, using eight to ten liters a minute. The patient is usually placed in a high Fowler's position as this is more comfortable and probably materially assists respiration. Unless there has been massive hemorrhage and a large per cent of the blood has not been given back via auto-transfusion, postoperative transfusions are not needed.

As pointed out above, in two of the cases 2,500 and 1,900 cc. were given back to the patient. Opiates are used sparingly since it is necessary for these patients to have as full an expansion as possible to assist in re-expansion of the left lung. A careful check must be made of the left thoracic cage periodically to discover pneumothorax or hemothorax before embarrassment of respiration takes place. In the average case one to two paracenteses twelve and thirty-six hours postoperatively usually takes care of any residual pneumothorax or exudate into the thoracic cage.

The patient is removed from the oxygen tent as soon as respiration and pulse approach normal. Serial electrocardiographs are taken as soon postoperatively as feasible and the electro-

cardiograph tracings will determine to a large extent when the patient should be allowed up. It has been our experience that relatively trivial heart wounds will give electrocardiographic tracings that will seem much more serious than the actual heart wound. It has been observed in wounds of the right ventricle near the atrioventricular groove without definite damage to the left coronary or to the anterior descending branch of the left coronary that there will be tracings consistent with a diagnosis of anterior infarction. Patients without damage to a major vessel or without extensive lacerations in the ventricles or auricles may usually be allowed out of bed within a week and out of the hospital within fifteen to twenty days.

#### CASE REPORTS

During the past six years thirty-three cases of wounds of the heart have been admitted to the Louisville General Hospital. In this group there have been twenty-three cases which have allowed time for diagnosis and treatment. Three of the patients died on the operating table before the chest could be opened. Seven expired between the time they were brought to the accident ward and were taken to surgery. The majority of the patients who were operated upon have been done by the chief resident at the time. The following are short résumés of each of the twenty-three patients operated upon:

CASE A-1. T. S., a colored male, age thirty-seven, was admitted sixty minutes after a stab wound in the fifth intercostal space to the left of the sternum. His blood pressure was 60/40; pulse 90; the venous pressure was increased. Fluoroscopy showed enlarged cardiac shadow. The patient was explored through a "T" incision, excising fourth and fifth costal cartilages. A lacerated wound of the right ventricle was found and sutured. The patient made an uneventful recovery and was discharged on the twenty-sixth hospital day.

CASE A-2. A. M., a colored female, age twenty-eight, was admitted an hour and thirty minutes after injury with a knife wound in the fifth intercostal space. Her blood pressure was 40/0; venous pressure and fluoroscopy were not done. The patient was opened through a "T" incision. A 1½ cm. laceration of the right ventricle was found, which was sutured. The patient died on the third postoperative day and autopsy revealed that five chordae tendineae had been severed. There had also been perforation of the interventricular sep-



tum. There were multiple mural thrombi over the wounds in the endocardium, as well as over the stumps of the chordae. Twelve hours prior to death the patient developed acute symptoms of cerebral embolism.

CASE A-3. V. D., a colored male, age forty-two, was admitted sixty minutes after injury with a stab wound in the second intercostal space to the left of the sternum. His blood pressure was 0; pulse 80. Fluoroscopy revealed enlarged cardiac shadow. Exploration through a horizontal incision placed over the stab wound revealed a laceration of the aorta and right ventricle. The laceration was sutured and the patient was discharged on the twenty-first hospital day.

CASE A-4. W. P., a colored male, age 30, with no history, was admitted with a stab wound over the third intercostal space to the left of the sternum. His blood pressure was 0; pulse 80; venous pressure 200 mm. of water. Fluoroscopy revealed enlarged cardiac shadow. The patient was explored through a horizontal incision over the fourth intercostal space. A laceration of the right ventricle was found and sutured; 1,900 cc. of blood were given to the patient via auto-transfusion and he was discharged on the twenty-fifth hospital day.

CASE A-5. V. S., a colored female, age nineteen, with no history, was admitted with a stab wound in the fifth intercostal space, 5 cm. to the left of the sternum. Her blood pressure was 0; pulse 90; venous pressure 220 mm. of water. Fluoroscopy showed enlarged cardiac shadow. The patient was explored through a horizontal incision over the fourth rib. A wound of the right ventricle was found and sutured. The patient was discharged on the twenty-second hospital day.

CASE A-6. B. C., a white male, age forty-four, with no history, was admitted with a wound over the fifth intercostal space, 6 cm. to the left of the sternum. His blood pressure was 0; pulse 90; increased venous pressure and widened cardiac shadow. He was explored through a horizontal incision over the fourth rib to the left of the sternum. A wound of the right ventricle was found and sutured and he left the hospital on the sixteenth postoperative day.

CASE A-7. F. W., a white male, age fifty, with no history, was admitted with a gunshot wound of the third intercostal space to the left of the sternum. His blood pressure was 0; pulse imperceptible; increased venous pressure and widened cardiac shadow. The patient was explored through a "T" incision over the fourth rib. A jagged wound of the right ventricle was found and sutured. This patient received 2,500 cc. of blood via auto-transfusion. He left the hospital on the twenty-fourth hospital day.

CASE A-8. M. R., a colored male, age twenty-three, was admitted twenty minutes after injury with a wound in the second intercostal space to the

left of the sternum and another wound in the mid-clavicular line in the same intercostal space. His blood pressure was 0; pulse imperceptible; venous pressure 210. Fluoroscopy was positive for increased cardiac shadow. The patient was explored through a "T" incision over the third rib and a laceration of the left ventricle was found and sutured. He was discharged on the eighteenth hospital day.

CASE A-9. W. B., a colored male, age thirty, admitted fifteen minutes after injury with a wound in the fourth intercostal space to the left of the sternum. His blood pressure was 50/30; pulse 60; fluoroscopy was positive. The patient was explored through a "T" incision over the fourth rib. A laceration of the left ventricle was found and sutured and he was discharged on the fourteenth hospital day.

CASE A-10. C. B., a colored male, age thirty, with no history, was admitted with a penetrating wound in the midline just below the tip of the xiphoid process. His blood pressure was 60/20; pulse 70; increased venous pressure and widened cardiac shadow. The patient was explored through a horizontal incision, removing a fragment of the sixth costal cartilage. A wound of the right ventricle was found and sutured and the patient was discharged on the nineteenth hospital day.

CASE A-11. W. C., a colored male, age twenty-three, with no history, was admitted with a blood pressure of 70/40; pulse 70; increased venous pressure and widened fluoroscopy shadow. When the patient was explored through a horizontal incision over the fifth rib, a wound of the left ventricle was found and sutured. He was discharged on the twentieth hospital day.

CASE A-12. J. W., a colored male, age twenty-seven, was admitted fifteen minutes after injury with a wound at the fourth intercostal space to the left of the sternum. The blood pressure was 0; pulse imperceptible; increased venous pressure and wide cardiac shadow. The patient was explored through a "T" incision over the fourth rib and a laceration of the right ventricle was found and sutured. He left the hospital on the eighteenth hospital day.

CASE A-13. W. T., a colored male, age fifty, was admitted fifteen minutes after injury caused by a stab wound of the third intercostal space to the right of the sternum. His blood pressure was 0; pulse 80. Fluoroscopy revealed an enlarged cardiac shadow. The patient was explored through a horizontal incision to the right of the sternum and a laceration of the right ventricle was found and sutured. He was discharged on the twenty-third hospital day.

CASE A-14. R. R., a white male, age twenty-three, was admitted with a gunshot wound of the fourth intercostal space to the left of the sternum.

His blood pressure was 80/60; pulse 80. Exploration through a horizontal incision to the left of the sternum revealed a jagged laceration of the right ventricle which was sutured. He was discharged on the thirtieth hospital day after an uneventful recovery.

CASE A-15. J. S., a colored male, age twenty-seven, with no history, was admitted with a gunshot wound just above the tip of the xiphoid. His blood pressure was 0; pulse 80. Fluoroscopy revealed an enlarged cardiac shadow. The patient was explored through a horizontal incision over the fifth rib to the left of the sternum. Exploration of the heart revealed a through-and-through wound of the right and left ventricles. The wounds were sutured but the patient died on the second postoperative day, apparently of gradual, continuous bleeding.

CASE A-16. J. K., a colored male, age forty-five, was admitted sixty minutes after a stab wound in the third intercostal space to the left of the sternum. His blood pressure was 0; pulse indiscernible; venous pressure increased. Fluoroscopy showed increased cardiac shadow. The patient was explored through a horizontal incision over the fourth rib to the left of the sternum and a wound of the left auricle was found and sutured. He made an uneventful recovery and was discharged on the twenty-fourth hospital day.

CASE A-17. C. T., a colored male, age twenty-nine, with no history, was admitted with a stab wound in the fifth intercostal space, 3 cm. to the left of the sternum. His blood pressure was 60/0; pulse 90 per minute; venous pressure was not taken. Fluoroscopy revealed enlarged cardiac shadow. The patient was explored through a "T" incision, removing the fourth rib. A wound of the right ventricle was found and sutured. He made an uneventful recovery and left the hospital on the twenty-fifth day.

CASE A-18. G. C., a colored male, age thirty-five (?), was admitted thirty minutes after injury with a 1½ em. stab wound in the fourth intercostal space to the left of the sternum. His blood pressure was 20/0; pulse 80. Fluoroscopy revealed an enlarged cardiac shadow. Exploration through a transverse incision revealed a 1 cm. laceration of the left auricle, which was sutured. Convalescence was uneventful and the patient was discharged on the thirtieth hospital day.

CASE A-19. W. M., a colored male, age twenty-two, was admitted thirty minutes after injury with a knife wound in the third intercostal space to the left of the sternum. His blood pressure was 0; pulse 100; venous pressure 180 mm. of water. Fluoroscopy revealed a markedly enlarged non-pulsatile cardiac shadow. The patient was explored through a horizontal incision placed to the left of the sternum. A laceration of the right ven-

tricle was found and sutured. He was discharged on the twenty-eighth hospital day.

CASE A-20. E. R., a colored male, age sixty-five, was brought into the accident ward with no definite history. He had received a stab wound of the second intercostal space to the left of the sternum. His blood pressure was 0; pulse 80. Fluoroscopy revealed an enlarged cardiac shadow. The patient was explored through a left horizontal incision over the fourth intercostal space, and a laceration of the left ventricle was found and sutured. He was discharged on the twenty-fourth hospital day.

CASE A-21. R. V., a white male, age forty-eight, was admitted thirty minutes after injury with a knife. He had a wound in the fourth intercostal space to the right of the sternum. His blood pressure was 0/0; pulse barely discernible. Fluoroscopy revealed an enlarged cardiac shadow. Exploration through a "T" incision in the fourth intercostal space revealed a 2 cm. laceration to the right of the right auricle. Convalescence was uneventful and the patient was discharged on the nineteenth hospital day.

CASE A-22. E. B., a colored female, age twenty-two, with no history, was admitted with a stab wound in the first intercostal space to the left of the sternum. Her blood pressure was 0; pulse unattainable; venous pressure and fluoroscopy were not done. The patient was explored through a "T" incision, removing fragments of the second and third costal cartilages. A wound of the left auricle was found and sutured. She left the hospital on the seventh postoperative day.

CASE A-23. D. F., a colored female, age twenty-eight, was admitted approximately thirty minutes after injury with a knife wound in the third intercostal space, just to the left of the sternum. A wound high on the right ventricle was found and sutured. Gelfoam was sutured over this laceration because of troublesome oozing. The patient made an uneventful recovery and was discharged on the thirteenth hospital day.

CASE B-1. C. M., a colored male, age thirty-nine, was admitted sixty minutes following a gunshot wound of the left chest just lateral to the nipple. His blood pressure was 0; pulse 100 per minute; venous pressure and fluoroscopy were not done. The patient was explored through a "T" incision placed over the left fourth rib. He expired before the pericardium was opened from tamponade plus massive hemorrhage. There were wounds of the left ventricle, left auricle and pulmonary vein.

CASE B-2. C. T., a colored male, age thirty-two, with no history, was admitted with a gunshot wound just above the xiphoid. His blood pressure was 0; pulse 90; venous pressure done on the operating table, while team was scrubbing, was 150.

The patient expired as surgery was being started. Autopsy revealed a through-and-through wound of the right ventricle with massive hemorrhage.

CASE B-3. T. H., a colored male, age thirty-five, with no history, was admitted with a stab wound in the fourth intercostal space. He expired on admission to the accident ward. No autopsy was attainable.

CASE B-4. C. L., a colored male, age thirty-seven, with no history, was admitted with a wound in the third intercostal space 6 cm. to the left of the sternum. The patient expired on admission to the accident ward and no autopsy was obtained.

CASE B-5. M. C., a colored female, age forty-five, with no history, was admitted with a massive wound of the left chest, involving the third, fourth and fifth costal cartilages. She expired on admission to the accident ward.

CASE B-6. W. B., a colored male, age thirty, with no history, was admitted with a gunshot wound of the second intercostal space 5 cm. to the left of the sternum. The patient died on the way to surgery. Autopsy revealed a through-and-through wound of the right ventricle and right auricle.

CASE B-7. C. L., a colored male, age thirty-seven, with no history, was admitted with a stab wound in the third intercostal space 6 cm. to the left of the sternum. The patient expired on the way to surgery. Autopsy revealed a wound of the right ventricle.

CASE B-8. M. C., a colored female, age fifteen, with no history, was admitted with a gunshot wound of the fifth intercostal space. She expired before the chest could be opened. There were through-and-through wounds of the right and left ventricles.

CASE B-9. C. P., a colored male, age thirty-five, with no history, was admitted with a wound in the anterior axillary line. The patient expired before surgery could be started. Autopsy revealed a wound of the left ventricle.

CASE A-10. Q. B., a white female, age thirty-two, was admitted with an ice pick wound in the fourth intercostal space just to the right of the sternum. The pick was still in place. Her blood pressure was 60/0; pulse 120; venous pressure, taken on the operating table, showed 220 mm. of water. As the chest was being opened through a transverse incision over the fourth rib, the patient went into ventricular fibrillation and expired. Autopsy revealed a jagged wound of the right and left ventricles.

#### SUMMARY

This series of penetrating wounds of the heart and pericardium includes twenty-three patients with cardiac wounds who were alive twenty minutes after admission to the hospital

which allowed time for diagnosis and surgery. There were two postoperative deaths in this series, one on the third and one on the second postoperative day. This presents a postoperative mortality of 8.69 per cent. (Table I.) All of the patients who died on admission to the

TABLE I

1941-1947

Cases admitted.....	33
Operated cases.....	23
Postoperative deaths.....	2
Mortality.....	8.69%

accident ward, expired on the way to the operating room or before surgery could be started died from exsanguination.

In our previous paper of 1941, we reported forty-seven cases of penetrating wounds of the heart and pericardium with a mortality of 25.9 per cent. (Table II.) This present series in-

TABLE II

1933-1941

Cases admitted.....	47
Operated cases.....	27
Postoperative deaths.....	7
Mortality.....	25.9%

cludes an additional thirty-three cases admitted with the diagnosis of cardiac wounds. This gives a total number of eighty cases in which the presumptive diagnosis of wound of the heart or pericardium was made. In this overall group there were twenty-three patients who died before surgery could be instituted. There were seven cases in the original series in which the presumptive diagnosis of a cardiac wound was not borne out at operation. Three had evidence of tamponade due to pressure of extrapericardial hematomas. In two there were massive hemorrhages into pleural cavities from large vessels, and in one there was a laceration of the pericardium and diaphragm but not of the heart. The seventh case has been discussed in detail by Badertscher.<sup>7</sup> There were fifty cases that allowed time for diagnosis and treatment with nine deaths, or an overall mortality of 18 per cent. (Table III.)

TABLE III

1933-1947

Cases admitted.....	80
Operated cases.....	50
Postoperative deaths.....	9
Mortality.....	18%

This decrease in the postoperative death percentage is a direct result of several factors. As brought out earlier in this paper, one factor

is education of the house staff and the staff in the accident ward so that immediate recognition of a cardiac wound is made and the patient is sent to surgery with a minimum of delay. A second factor that is of extreme importance is the teaching of the Chief Resident in Surgery

TABLE IV  
1938-1947

Operated cases.....	36
Postoperative deaths.....	3
Mortality.....	8.33%

the technic of dealing with cardiac wounds so that surgery may be begun within twenty or thirty minutes after admission to the hospital rather than having to delay operation until the Chief of Staff or some other member of the staff interested in these cases comes "across town." An interval of fifteen to thirty minutes may mean the difference between life and death to the patient. In this series and the series reported previously, the Chief Resident at the time did more than 75 per cent of the cases. A third factor that is of importance is an operating suite that is open and ready twenty-four hours a day with a major setup ready and sterile at all times. During the time that the team is scrubbing up, the nurse in charge may quickly sterilize any special instruments that may be needed in a cardiac wound in one of the high-speed instrument sterilizers that are available today. The importance that these factors play in the successful treatment of cardiac wounds is reflected in the fact that in the last thirty-six patients with cardiac wounds who were alive twenty minutes after admission to the accident ward, which allowed time for diagnosis and treatment, there were only three deaths with a mortality of 8.33 per cent. (Table IV.)

The most frequent cause of death in the postoperative cases has been cerebral embolism secondary to mural thrombi forming at the sites of perforation of the endocardium. It might be mentioned here that there is probably a place for the use of some of the anticoagulant drugs postoperatively when the surgeon is reasonably sure that there has been perforation of the endocardium. It is believed by the authors that in any wound of the auricles some form of anticoagulant should be used. In any wound of the auricles it is practically impossible to place sutures without entering the auricular cavity. The use of heparin has been mentioned previously by Bigger.<sup>8</sup>

We also believe that there is another important usable material that has been introduced into this field in the form of Gelfoam, or some similar substance, as has been advocated by Jenkins. Many of the wounds of the ventricles that continue to ooze may be controlled with the use of one of these substances and it has a very definite place in the treatment in wounds of the auricles.

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#### DISCUSSION

LOUIS G. HERRMANN (Cincinnati, Ohio): Dr. Maguire and Dr. Griswold have presented a remarkable group of patients with wounds of the heart and pericardium. They have covered their subject so well that there is little that I can add so I shall re-emphasize some of the things they have already presented. We are convinced that injuries to the heart and great blood vessels occur sufficiently often in wounds of violence that a thorough re-evaluation of our surgical methods and our physical equipment for the proper management of these injuries should be made by all of us.

It is absolutely essential that the resident surgeons of our larger hospitals remain alert at all times for such vascular injuries since too much delay in carrying out definitive treatment always means failure to save the life or the limb of the injured person. In the discussion of injuries to large blood vessels which was presented yesterday, we emphasized the fact that proper supportive treatment with whole blood and fluids will usually permit even extensive surgical procedures in patients with injuries to the heart or large blood vessels without serious complications if the basic principles of vascular surgery are constantly observed during the operation.

Prompt diagnosis of the site and kind of injury with as little delay as possible in transporting the patient to the operating room is an essential part of definitive treatment. The operation itself should not be hurried and we must never permit improper preparation of the operative field in the quest for speed. Serious wound infection with secondary chondritis has followed such neglect of proper preparation of the skin of the thorax before operation.

I must emphasize the importance of the use of a solution of novocain on the surface of the exposed heart. This simple procedure will permit the handling of the heart without causing the rhythm to become seriously altered. We have also observed that the irritability of heart is greatly reduced by this simple measure and in several cases in which the injury caused serious irregularity of the heart action the application of novocain to the surface of the heart restored normal rhythm promptly and the operation could then be completed without further difficulty.

Dr. Griswold and his associates should be commended for the fine work which they have done during the past decade in the management of wounds of the heart. In Cincinnati we have observed more injuries to large blood vessels and fewer injuries to the heart. We believe, however, that the surgical problems are the same for all such vascular injuries.

Much progress has been made during the past ten years in this field of vascular surgery and we must now alter our attitude toward such injuries and insist that they receive immediate and adequate care. We should analyze the facilities for the management of such injuries in all the hospitals in which we work and we must make every effort to acquaint our younger surgeons and particularly our resident surgeons with the principles upon which success in vascular surgery is based. We will save many lives and many limbs if we remain alert to these important surgical emergencies.

JAMES M. WINFIELD (New York, N. Y.): It is indeed a great pleasure and honor to discuss the most interesting presentation of Dr. Griswold and Dr. Maguire. In a review of thirty-two cases at the Detroit Receiving Hospital, it will be found that the method of production or causation of these injuries very nearly parallels that of the authors, with this difference: We had a relatively higher degree of wounds from ice picks than from gunshot and we had a smaller total number of gunshot wounds. We had no infections but had one very serious effusion, this occurring in a patient who had the right pulmonary artery injured. This artery was injured from a wound that came from the left side, about half-way between the mid-portion of the sternum and the nipple.

I think the mortality that the authors have re-

ported is amazing. Our mortality, overall mortality, was 22.2 per cent. In the diagnosis, naturally, every patient has to be individualized, but there are certain things that I think should be emphasized: One is the history of what happened to this patient when he was injured. The shock is usually out of all proportion to the evident wound. Frequently, if you get them early, you will see very profuse bleeding from a small wound over the cardiac area and that should make one suspicious.

There are several points which I would like to emphasize. I certainly agree that there is no excessive "rush" about operating upon these patients. That is a relative thing. But the business of driving them up to the operating room and performing a heroic surgical procedure on a moribund patient is not usually necessary or wise. Time, as a rule, can be taken to carry out supportive measures. We have lately been performing more pericardial taps. We had three patients who were injured by ice picks that were tapped once (each one of them only once), and we decompressed the tamponade. The patients had all the signs and symptoms of tamponade to a small degree but it was present. They recovered without any difficulty.

Dr. Blalock, Dr. Bigger, Dr. Churchill and others have emphasized that pericardial tap to decrease the tamponade is often a life-saving measure, and if you withdraw the blood and at the same time start giving them blood and preparing the patients for operation, their condition may be immeasurably better when you get in there.

Another point is anesthesia. I emphasize anesthesia because without positive pressure anesthesia, that is, under local or improperly given inhalation anesthesia, the operation is tremendously difficult as compared to this type of operation when good anesthesia is given under positive pressure.

A high oxygen content with nitrous oxygen oxide is the best anesthesia.

We do not sew the pericardium but drain it into the pleural cavity. It is remarkable that patients who suffer severe cardiac wounds have so few sequelae after recovery from the operative procedure. As a rule, they are able to carry on their usual work, and from this standpoint repair of the injured heart gives very gratifying results.

Again, I would like to say how much I appreciated hearing this paper.

CHARLES HUGH MAGUIRE (closing): I certainly appreciate Dr. Herrmann's and Dr. Winfield's remarks. There is one thing I would like to re-emphasize that Dr. Winfield emphasized, and that is, the tremendous come-back that many of these people make, even with relatively extensive cardiac wounds.

I mentioned a while ago that we routinely run postoperative electrocardiographic tracings on

these people as soon as feasible. One interesting observation that has completely upset our cardiologists has been the finding that in relatively trivial wounds of the right ventricle, close to the atrioventricular groove, without apparent damage to any of the major coronary vessels, practically a 100 per cent will have tracings which are consistent with anterior infarction. That finding will persist frequently for a matter of a week or ten days and then gradually return to normal.

The cardiac reserve in these people, even when they have had extensive wounds of the myocardium, is tremendous. Most of these colored boys are common laborers and, of course, drunks on Friday and Saturday, but they return to their hard labor without any evidence of residual cardiac damage. One boy in our previous series, that we are reporting separately later, had complete division of his left coronary. I do not know whether you re-

member the original wound slide, but there was one heart wound which entered both the left auricle and left ventricle and had severed his left coronary. The wound actually was big enough for me to put the tips of two fingers into it and the tip of the third finger as a plug while we were placing the sutures. On the operating table, the entire anterior surface of the right ventricle became cyanotic; there were circus movements in this cyanotic area. Novocain controlled these irregular contractions. He had electrocardiographic findings consistent with massive anterior infarction. That finding persisted for as long as two months. However, he gradually reverted to a normal electrocardiogram and at the present time, which is about five years postoperatively, he has been back to hard manual labor for a matter of four years.

I appreciate the discussion, and it has been a pleasure to be here.



# USE OF CUTIS GRAFT MATERIAL IN THE TREATMENT OF TRAUMA AND ITS RESULTS

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OUR understanding is that cutis is skin from which an epidermal layer of very moderate thickness has been removed (usually with a skin graft razor). Cutis possesses great value as replacement material in the course of the repair of traumatic or other defects in aponeurotic structures in various parts of the body; in the repair of certain fractures such as those of the patella; for the binding together of certain longitudinal long bone fractures, it is a superior substitute for the Parham band; it constitutes satisfactory plastic repair material for use in the Nieola or Henderson type of operation for the relief of chronic recurrent types of shoulder dislocation.

*Technic.* For quite some time we have been using alloy stainless steel wire for the purpose of closing defects in the aponeurotic structures, likewise for suturing the cutis graft into position.

*Hernia.* The aim in general in regard to hernial repair and reenforcement is to make the best possible closure under the conditions present, after which the reenforcing layer is applied snugly. Not infrequently a modified plastic operation (lipectomy) of the abdominal wall in the immediate area of the hernia improves the contour considerably. A pressure dressing of mechanic's waste usually is applied and kept in place for ten days to two weeks.

As repair and replacement material cutis possesses many advantages such as ready availability, prompt healing in, apparent absence of foreign body reaction. It may be used in as many layers as may be needed to give adequate strength.

In regard to its use for ligation of the large vessels (arterial or venous) our use indicates that cutis is in every way satisfactory for this purpose.

*Technic for Ligation of Large Vessels.* The strip of cutis is carried twice around the vessel, clamped in that position, and held firmly with a curved hemostat while transfixion cotton ligatures are placed and tied so as to secure the strip of cutis firmly against any possibility of

slipping. By contrast, ligatures of rubber, likewise those of cotton tape, may cut through a large vessel.

From the standpoint of trauma, use of cutis graft material has been made by some of my surgical associates and me for the replacement of aponeurotic tissues that have been destroyed in various areas of the body, clinically seen as defects in the aponeurotic layers of the abdominal wall; for the repair of destroyed areas of dura incidental to gunshot wounds or other causes (Case I); for the control and alleviation by stage, also immediate, ligation of the common carotid artery, certain types of cerebral aneurysms (Cases II and III); for the ligation of large veins (for instance, the vena cava) incidental to the treatment of thrombosis and embolism (Cases IV and V); for approximation of the third and fourth metacarpal bones in clawhand; for the surgical treatment of ankylosis of the jaw; in the reduction of sterno-clavicular dislocation (Cases VIII and IX); in the treatment of unstable knee (Case VII); for the repair and reenforcement of ruptured muscle sheaths (Case VI); for the repair of certain types of hernia; for the repair of diastasis of the buccinator muscle (glass blower's hernia); in the reduction of fracture of the patella; in the treatment of fracture of the ulna; in the reduction of acromioclavicular dislocation; for the repair of contour defects over depressed areas in the frontal bone and for implantation graft after sequestrectomy for chronic discharging sinus of the foot.

## CASE REPORTS

CASE I. E. A., a male, white, age fifteen, was admitted to the Charleston General Hospital after having received a shotgun charge (bird shot) at close range in the right temporal area. There was considerable destruction of the soft tissue, bone, dura and brain.

Operation was performed by Dr. A. A. Wilson and Dr. Joseph Haber. The dural rent was cleansed by irrigation and débrided; it was closed by a cutis graft patch 1 inch (2.5 cm.) square. A sliding flap of adjacent scalp was brought down and sutured



in place so as to cover the large defect in the skin. The result has been very satisfactory.

**CASE II.** Mr. J. B. S., age sixty-two, white, complained of ringing in the ears and of a painful and pronounced exophthalmos of the left eye. He had fallen down a flight of steps in a hotel twenty-seven days prior to admission to the hospital and apparently had suffered severe concussion. There was complete left ophthalmoplegia with pronounced exophthalmos and extreme edema of the conjunctiva. No evidence of intracranial pressure was noted. The patient remembered none of the events of the accident. There was a loud bruit which could be heard all over the forehead and adjacent areas of the head but perhaps was heard best around the left eye; hence, it was assumed that the patient had an arteriovenous fistula.

Operation was performed January 31, 1945, by Dr. A. A. Wilson, on whose service the patient was admitted to the hospital. An incision was made in the left side of the neck and carried downward so as to expose the common carotid artery just below its bifurcation. A rubber-shod clamp was applied to the carotid artery for twenty minutes with no untoward reaction. A  $\frac{1}{2}$  inch (1.3 cm.) wide strip of cutis was wrapped twice around the common carotid artery and held sufficiently taut to obliterate, almost but not completely, the pulsation. The strip was anchored firmly in position with interrupted cotton thread sutures. At that point in the operation it was noted that the bruit ceased immediately. The wound was closed in layers with fine silk.

Eight days later the wound of the previous operation was opened and the carotid artery exposed. Three ligatures of heavy black silk were tied tightly around the encircling strip of cutis, after which the weak pulsations distal to the cutis ligature ceased. The wound was closed in layers with fine black silk.

Doctor Wilson states that this patient has recovered completely. There has been no return of the bruit and the exophthalmos in the left eye has disappeared entirely.

**CASE III.** M. P., a colored female, age thirty-one, was admitted to the Charleston General Hospital on the neurologic service, complaining of pain over the right eye and ptosis of the right eyelid. The diagnosis of cerebral aneurysm, anterior cerebral artery, was made.

Operation was performed May 27, 1947, by Dr. Charles J. Harkrader, Jr., chief surgical resident. Cutis graft ligation of the common carotid artery was done and the patient was relieved of her symptoms almost immediately.

**CASE IV.** Mrs. A. T., a white female, age sixty, complained of a painful left leg due to thrombophlebitis of numerous veins of the left leg and thigh which had occurred following a week in bed with influenza. Ligation of the vena cava was decided upon.

Operation was performed April 7, 1947, by Dr. John E. Cannaday. The vena cava was exposed retroperitoneally through a lower abdominal transverse incision, and a short length mobilized by finger dissection. The vena cava then was ligated with a strip of cutis passed twice around it and anchored with double No. 30 cotton thread sutures. The patient's symptoms were relieved at the time she left the hospital, April 25th, and she stated that she was feeling well.

**CASE V.** G. H., a white male, age sixty-four was admitted to the second medical service of the Charleston General Hospital, April 25, 1947, with thrombophlebitis of the right leg and pulmonary infarction of the right side of the chest. In spite of treatment with dicumarol the patient's temperature continued to run septically and vena cava ligation was decided upon.

Operation was performed April 29, 1947, by Dr. John E. Cannaday. An incision was made in the right flank at the level of the umbilicus. The vena cava was exposed retroperitoneally by blunt dissection and isolated at the level of the bifurcation of the aorta. A strip of cutis was carried twice around the vena cava, drawn snugly and firmly anchored with interrupted cotton thread sutures. At the time of the patient's discharge from the hospital (May 11th) his condition was quite satisfactory.

**CASE VI.** S. F., a white man, age forty-five, was admitted to the Charleston General with a history of severe trauma to the calf of the right leg after which a painful bulge developed on the back of the injured leg below the knee. The hernial bulge was about  $2\frac{1}{4}$  by  $2\frac{3}{4}$  inches (6 by 6.9 cm.). A cutis graft repair was done by Dr. John E. Cannaday. The patient had an apparent good result following the primary operation, but later sustained a secondary injury of the leg involved, with apparent recurrence of some of the previous symptoms. At a second operation the aponeurotic structures of the calf of the leg were resutured with apparent satisfactory results to date.

**CASE VII.** Miss D. W., a white woman, age nineteen, was operated on November 30, 1944, by Dr. George Tsunekawa and the writer for the reconstruction of the crucial ligaments of the knee. The crucial ligaments were repaired with a heavy strip of cutis graft material. Immediate results were excellent and, according to a report from her physician several months ago, her condition still was excellent, with normal function.

**CASE VIII.** B. S., a white male, age not noted, was operated on by Dr. George Miyakawa October 18, 1944, for the cutis graft repair of a dislocation of the right sternoclavicular joint. A cutis strip was passed through a previously made quarter-inch drill hole in the superior portion of the sternum, then introduced in the previously made somewhat similar hole in the proximal end of the

clavicle. The two ends of the graft then were sewed back on the graft under considerable tension with cotton thread sutures. The result in this case has been very satisfactory.

CASE IX. R. R., a white male, age not noted, was operated on September 19, 1945, by Dr. George Miyakawa for the repair of a right sterno-clavicular dislocation. The cutis graft technic, as reported in the preceding case, was followed, and the results have been excellent.

#### COMMENT

The ligations of the vena cava reported in Cases IV and V were done with a view to the alleviation of an ascending thrombosis and embolism involving the right leg and thigh. Cutis tissue was used as ligature material in both of these cases. Since thrombosis and embolism not infrequently follow traumatism of

the lower extremities, it was thought advisable to report these ligations. It has been observed that the structures of the vena cava are rather fragile. Special care, therefore, must be taken in order to prevent injury of this vessel.

#### CONCLUSIONS

As I have concluded in previous reviews of our experience with cutis, its greatest value probably lies in its use as a reenforcing graft in the treatment of certain types of hernia. However, it is of great value in the reconstruction of joints, also when used for reenforcement and replacement purposes in the repair of ruptured ligaments of the knee. It has been found to be excellent material for the stage or immediate ligation of large arteries.



# SURGICAL TREATMENT OF IRRADIATION DERMATITIS AND CARCINOMA

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**I**RRADIATION injuries to the superficial tissues may be divided into the following categories: 1. Acute burn; 2. chronic dermatitis and 3. chronic ulcers with malignant degeneration.

The damage to tissue may result from exposure to x-irradiation or radium emanations. Injuries result usually from misuse of these agencies but in some instances proper dosage of carefully calibrated x-rays or radium has produced disastrous results. Just why a given dosage of irradiation will produce only erythema and pigmentation of the skin in one patient and chronic dermatitis with malignant ulceration in another is difficult to explain. It seems inescapable that individual variations in susceptibility must explain these unusual instances.

The underlying pathologic process is fundamentally the same in the various categories of irradiation effect. In the acute burn there is necrosis of the skin with adjacent areas of edema and cellular infiltration, comparable to that found in a superficial burn due to any other agent. In the chronic states, however, perivascular infiltration becomes apparent and it is the progression of this process which leads to further necrosis, followed by fibrosis and still more perivascular round cell infiltration. It is apparently the repeated ulceration and healing of skin which is poorly vascularized which eventually produces a malignant change.

## ACUTE BURN

Treatment of the acute x-ray or radium burn is largely medical. The following cases illustrate the types of acute irradiation necrosis which require surgical intervention.

**CASE 1.** A man fifty-six years of age was treated by external x-irradiation for a fungus infection of the palm of the hand and fingers. He was accidentally given a longer exposure than planned. Within a few days the entire palmar surface of the hand and fingers became beefy red, edematous and extremely painful. Within the next three weeks the entire palmar skin became necrotic

and gradually sloughed. There was at first some tendency for the cutaneous margins to show evidence of epidermal proliferation but gradually this ceased and further necrosis took place. At the end of two months the palmar aspect of the hand and fingers was completely denuded of skin and fascia and the tendons presented masses of necrotic slough. The hand at this stage was extremely painful and the patient frequently required opiates for relief. At this stage it was obvious that the entire palmar skin, fat, fascia, flexor tendons, nerves and intrinsic muscles had been destroyed. Since any sort of plastic reconstruction could not possibly provide a useful hand amputation was performed in the distal third of the forearm.

**CASE 11.** A male sixty-nine years of age received seven x-ray treatments for "plantar warts" on the left foot. When seen some six months later he presented a necrotic ulcer 3 cm. in diameter on the plantar surface of the foot, centered over the metatarsophalangeal joint of the middle toe. The ulcer was surrounded by a 1 cm. areola of dense, avascular scar. The base of the ulcer was painful on direct pressure but showed no tendency to bleed.

*Comment.* X-ray burns of the type illustrated in Case 11, involving as they do a weight-bearing surface, are among the most difficult to treat successfully at any age but particularly so when the added handicap of peripheral arteriosclerosis is also present. A certain number of these burns will heal in younger individuals with bed rest, lack of weight bearing and mechanical cleansing and will remain healed if the plantar surface of the foot is judiciously padded to prevent pressure upon the callous which inevitably forms at the point of closure. If, however, the ulcer fails to heal or remain healed under such conservative management, one of the following methods of treatment is advised: (1) Excision, wide undermining of the surrounding plantar skin and closure; (2) Excision and application of free grafts; i.e., either thick-split grafts or multiple, small, deep grafts "nested" or packed closely together and (3) Excision and pedicle graft from the opposite leg.

Of the three methods enumerated the first

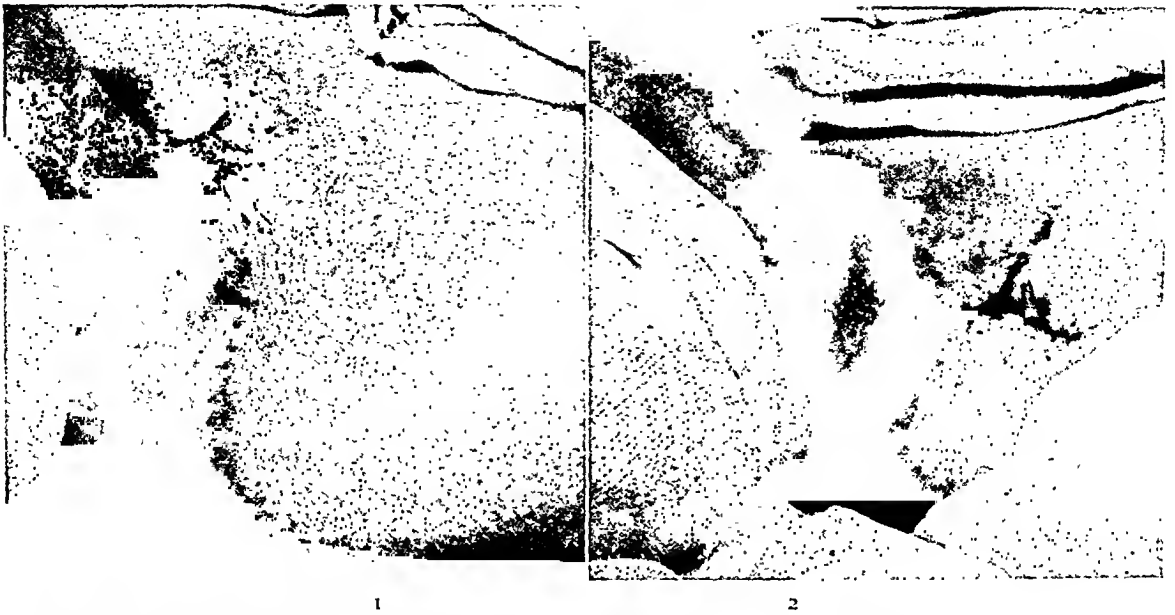


FIG. 1. Case III. Irradiation dermatitis of the supraclavicular region.

FIG. 2. Case III. The area of dermatitis has been excised and closed in inverted "Y," by sliding flaps of normal skin.



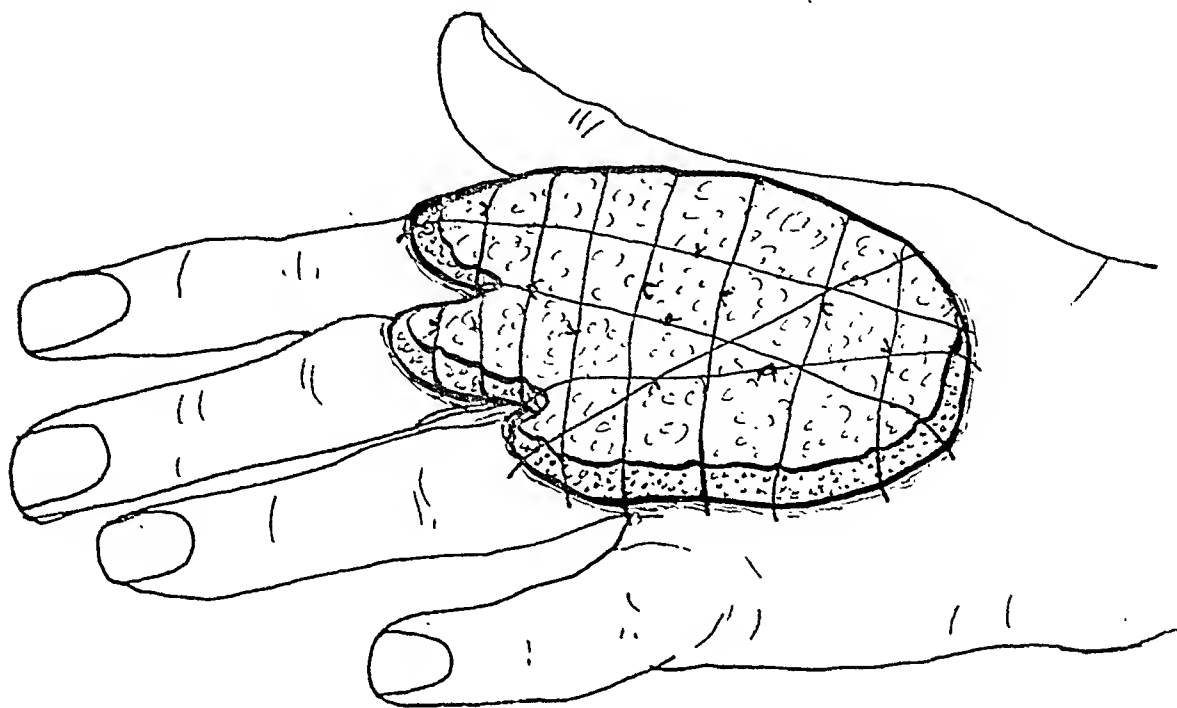
FIG. 3. Case IV. Irradiation dermatitis of the left hand twelve years after treatment of benign cutaneous lesions.

is the simplest and usually merits a trial before resorting to a graft. The avascular scar must be adequately but not widely excised and the undermining of plantar skin must be wide enough to allow easy approximation of the edges without any tension. In addition to fine approximating sutures several tension sutures should be placed and left in place until the edges are completely healed. Fine tantalum

wire sutures applied in vertical mattress form and tied over buttons of tantalum foil cause little tissue reaction and may be left in place for three weeks. Weight bearing should be avoided for three or four weeks and after that time the line of closure protected with felt pads. If primary excision and closure fails, a free graft is worth a trial because of its relative simplicity but few free grafts are permanently

satisfactory on the sole of the foot. A pedicle flap from the opposite leg offers the best opportunity for satisfactory closure of the ulcer but the following disadvantages are inherent in the method: (1) long immobilization of the extremities is hazardous in older individuals

who have a tendency to develop restriction of joint movement; (2) the transplanted skin does not always tolerate weight bearing well and (3) callosities tend to form at the junction line between the margins of the flap and the surrounding plantar skin. For the reasons enum-



A

FIG. 4. A, Case IV. Sutures about the margin of the dermatome graft have been tied over rubber sponge cut accurately to fit the defect.



B

FIG. 4. B, Case IV. The appearance of the dermatome graft is shown immediately after removal of the sponge rubber on the sixth postoperative day.

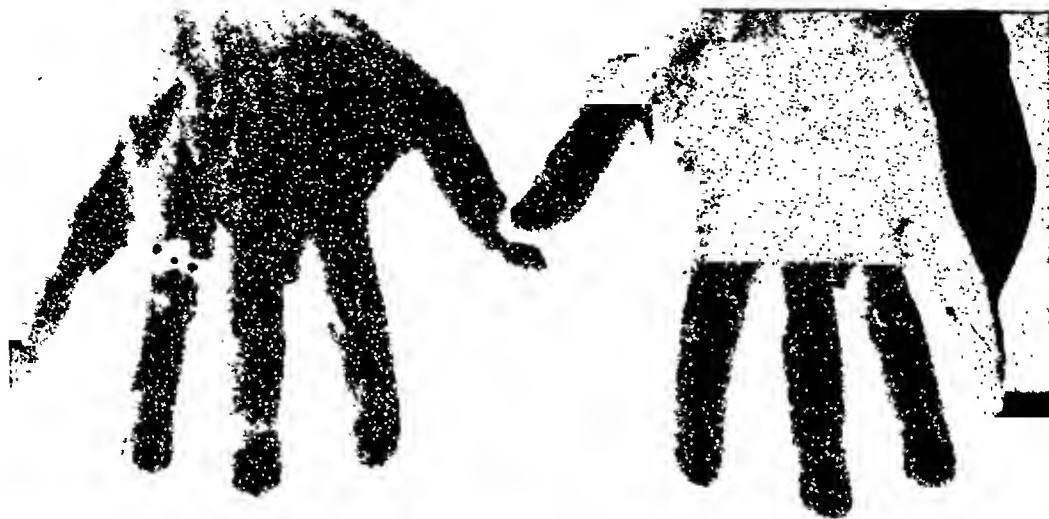


FIG. 5. Case IV. Comparison of the grafted hand (left) with the uninvolved hand (right) three months after operation.

erated pedicle grafts are usually reserved for those patients in whom other methods have failed. During the first few months of weight bearing on a plantar flap its cutaneous covering may break down at pressure points but with meticulous cleanliness, a well fitted shoe and careful padding the skin finally toughens and will tolerate constant use.

#### CHRONIC IRRADIATION DERMATITIS

Chronic skin changes may follow immediately upon the healing of an acute x-ray or radium burn or may appear years after the treatment was received without intervening symptoms or signs. Frequently the dermatitis appears within a few months of treatment and is continuous. The skin changes are characterized by the shiny, tense, mottled appearance, with many telangiectases and often areas of atrophy with scattered brownish pigmentation. The involved skin shows lack of elasticity and blanches when under tension. At first, pain is not present but with passage of time and thickening of the involved skin, pruritis is almost constant. In those areas which finally become malignant pain is often very severe. Areas of irradiation dermatitis which have been present for years tend to form vesicles and cracks which, subsequently, crust while the telangiectases occasionally bleed. When the latter changes appear malignancy should always be suspected.

#### MALIGNANT ULCER

The indolent ulcer in an area of irradiated skin is likely to prove malignant, although

many persist for years without showing malignant change. Microscopic section is the only certain method of differentiation. The malignant lesion may vary from a superficial ulceration to a deep, penetrating ulcer with irregular margins and necrotic base. The isolated ulcer often proves to be a prickle cell carcinoma although it may occasionally show characteristics of both basal and squamous cell lesions. The typical basal cell carcinoma occurring in irradiated skin is prone to occur in papules or multiple nodules which tend to coalesce and ulcerate superficially. The latter are often more difficult to treat because of their tendency to invade superficial fascial planes and extend beyond the area of cutaneous involvement. The basal cell lesions are also more likely to occur in irradiated skin which has shown no previous changes many years after the treatment was given. Regional lymph node involvement by the carcinoma is unusual and disseminated metastases are rare. Several patients have been observed with irradiation carcinoma over a period of years without lymph node involvement. Radical surgical removal of the local lesion and the irradiated areas offers the patient a good prognosis. Although statistics are few it is the opinion of the author that the prognosis of the squamous cell carcinoma arising in irradiated skin is somewhat better than that of the basal cell carcinoma.

#### SOURCES OF IRRADIATION

The diagnosis for which irradiation was given in the patients observed by the author has been varied. Following is a partial list

which does not include numerous, small, irradiated scars which were simply excised:

Plantar warts.....	10
Dermatitis of face.....	5
Dermatitis of hands.....	5
Pigmented nevi.....	5
Carcinoma of breast (postoperative).....	5
Lupus of face and neck.....	4
Vascular nevi.....	4
Uterine fibroids.....	3
Keloids from burns.....	3
Hypertrichosis.....	2
Mixed tumor of parotid.....	2
Portwine nevus.....	1
Sterilization.....	1
Benign breast tumor.....	1
Perineal epidermophytosis.....	1

X-irradiation was given in the majority of patients, radium in a few. Treatments were given by general practitioners, dermatologists and radiologists. The time interval between irradiation and surgical treatment varied from three months to thirty-five years.

#### RATIONALE OF SURGICAL TREATMENT

The removal of areas of irradiated skin is indicated in some instances for purely cosmetic reasons and in others because of pain or dysfunction of the affected part. The prophylactic removal of areas of irradiation dermatitis, especially those showing evidence of ulceration, is advisable. No reliable statistics are available to indicate the true incidence of carcinoma in areas of irradiation dermatitis but our impression is that the eventual incidence is high. That is to say, the patient with a large area of severe irradiation dermatitis probably stands a better than even chance of developing carcinoma if he lives long enough. The majority of the malignant lesions we have treated occurred from ten to thirty-five years after irradiation. The following cases illustrate the problems of surgical treatment:

**CASE III.** *Benign irradiation dermatitis of the neck:* The patient, a female of fifty years of age, received external irradiation for treatment of a breast lesion fifteen years ago and the lower cervical region was included in the field. There had been an area of unsightly dermatitis in the lower cervical and supraclavicular regions on the right side for several years but within the past year it had thickened, become itchy and the telangectases had occasionally bled. The patient presented a mottled area of atrophic skin in the lower cervical and right supraclavicular region about 12 cm. in diameter. (Fig. 1.) This area was excised and closed in an

inverted "Y" after mobilizing adjacent flaps of normal skin. (Fig. 2.) Microscopic section showed no evidence of malignancy.

**Comment.** Single or multiple excisions of irradiated skin are practical in the neck and abdominal wall when the surrounding skin lends itself to wide undermining and mobilization of flaps. The cosmetic result of such excisions is better than replacement with free grafts.

**CASE IV.** *Benign irradiation dermatitis of the hand:* Fifteen years prior to observation, the patient, a man of thirty-five years of age, had received external irradiation for dermatitis of the left hand. In the past two years an area of mottled, telangectatic, atrophic skin covering most of the dorsum of the hand and fingers had thickened and was prone to crack frequently with hard use or exposure to extremes of temperature. (Fig. 3.) Because of the hazard of malignancy in a region exposed to constant trauma, excision and free graft were advised. Most of the skin of the volar surface of the hand was excised down to the areolar layer over the extensor tendons. A dermatome graft of 16 micra thickness was cut from the inner aspect of the thigh and shaped to fit the defect, the graft being cut on the dermatome drum about 10 per cent larger than the defect. The graft was sutured into the defect, the sutures being left long and they were tied over a piece of sponge rubber cut to fit the defect exactly. At the end of six days when the sponge rubber was removed the graft was completely vascularized. (Figs. 4A and B.) At the end of three months the appearance of the skin was practically normal. (Fig. 5.)

**Comment.** Dermatome grafts are ideal for resurfacing the dorsum of the hand and they take well even on an irradiated base if the cicatricial tissue is completely removed. It is important to set the grafts in under slightly less than normal skin tension if maximum elasticity is to be obtained. It is also desirable that the margins of the defect be regular and that the graft be sutured meticulously to them with the finest suture material available. The sutures may be either continuous or interrupted. When the sponge rubber technic is used it is advantageous to place sutures every 1 to 1.5 cm. and to leave long enough ends to tie over the rubber.

#### SPONGE RUBBER TECHNIC

To insure a perfect "take" of a free graft on an irregular surface, it is axiomatic that the graft must be maintained in complete apposition to the base for at least two days. For the past ten years we have found sheets of sponge





FIG. 6. Case v. Irradiation dermatitis with ulceration in a port-wine nevus.

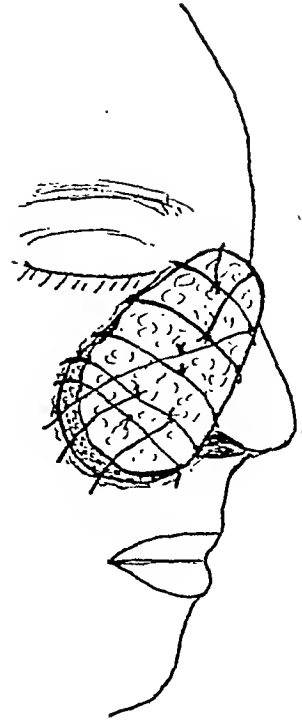


FIG. 7. A, Case v. Sutures about the margin of the dermatome graft tied over sponge rubber cut to fit the defect.



7B



8

FIG. 7. B, Case v. Photograph showing the sponge rubber still in place after removal of sutures.  
FIG. 8. Case v. Appearance of the dermatome graft after removal of the sponge rubber mold on the seventh postoperative day.

rubber ideal for this purpose. Sponge rubber of even texture is selected from which an elastic mold may be cut which exactly corresponds to the contour of the defect. The sponge rubber molds vary in thickness from 1 to 2.5 cm. depending upon the depth of the defect. One or two layers of plain cotton bandage gauze are placed between the graft and the rubber sponge to avoid sticking. The suture ends are tied loosely over the rubber mold thus providing complete fixation. Part of the sutures are cut at the end of two or three days to obviate tension due to edema and the sponge rubber is peeled off in from five to seven days. This method has been found particularly useful in repairing defects on the face and hands when other methods of fixation are likely to fail. (Figs. 4A and 7A.)

**CASE V. Irradiation dermatitis in a portwine nevus:** A male patient, fifty-five years of age, received external irradiation for a portwine nevus of the right side of the face ten years before our observation. For the past two years an area on the right side of the nose and cheek had broken down repeatedly. This area had been curetted and biopsied several times by a competent dermatologist but had failed to heal completely. The biopsies had been negative. Because of the threat of malignancy and the inconvenience of repeated ulceration, excision and skin graft seemed indicated. (Fig. 6.) The area of maximum irradiation damage, together with some of the most obvious surrounding portwine nevus, were excised down to the facial muscles and replaced with a thick dermatome graft. Figure 7 shows the area covered with the sponge rubber mold after removal of the sutures while the appearance of the grafted area at seven days is shown in Figure 8. Microscopic sections of the excised skin showed no evidence of malignancy. At this time the grafted skin, while not a perfect match, had already begun to blend well with the surrounding skin and seemed to justify the use of a thick dermatome graft rather than a full-thickness free graft or pedicle flap.

**Comment.** In the case just recorded a pedicle graft of skin by means of a temporal flap or a cervical flap would have provided more nearly ideal skin for replacement, but these were decided against by the preference of the patient and the time and economic factors involved in such procedures, realizing that a free graft might give less perfect replacement. A thick dermatome graft was used in preference to a free full-thickness graft from the postauricular region because of the size of the graft required and the fact that a thick dermatome graft ap-



FIG. 9. Case VI. Large irradiation ulcer of the cheek twelve years after treatment of mixed tumor of the parotid. A cervicothoracic flap has been prepared to fill the defect after resection. The ulcer was benign.

plied as herein described provides skin of almost equal texture with less hazard of skin loss. The use of a cosmetic preparation to match the color of the grafted skin to the normal and to minimize the borders of portwine nevus remaining make its presence scarcely obvious during the months required for the new skin to assume approximately normal color. If its final color is not perfect, pigment tattooing may be used to improve the match. In the case described it seems improbable that this will be necessary.

**CASE VI. Chronic irradiation ulcer of cheek:** A female patient, fifty-seven years of age, received external irradiation on the left cheek and neck following removal of a mixed tumor of the left parotid gland twelve years prior to admission. For two years prior to admission there had been a large, painful area of granulation over the margin of the left mandible, cheek and submaxillary region which had responded to none of various methods of treatment. A large, avascular ulcer presented, approximately 6 by 10 cm., on the left cheek and submaxillary region across the mid-portion of which the margin of the mandible stood out in relief although covered by granulations. A cervicothoracic flap was prepared in stages (Fig. 9), the entire necrotic area was excised together with the margin of the mandible and the distal end of the flap was set into the anterior end of the defect. The remainder of the defect was covered temporarily with a dermatome graft from the thigh until the proximal end of the flap could be turned around to cover the defect adequately. The microscopic



FIG. 10. Case VII. Malignant irradiation dermatitis of the right hand following treatment for fungus infection.

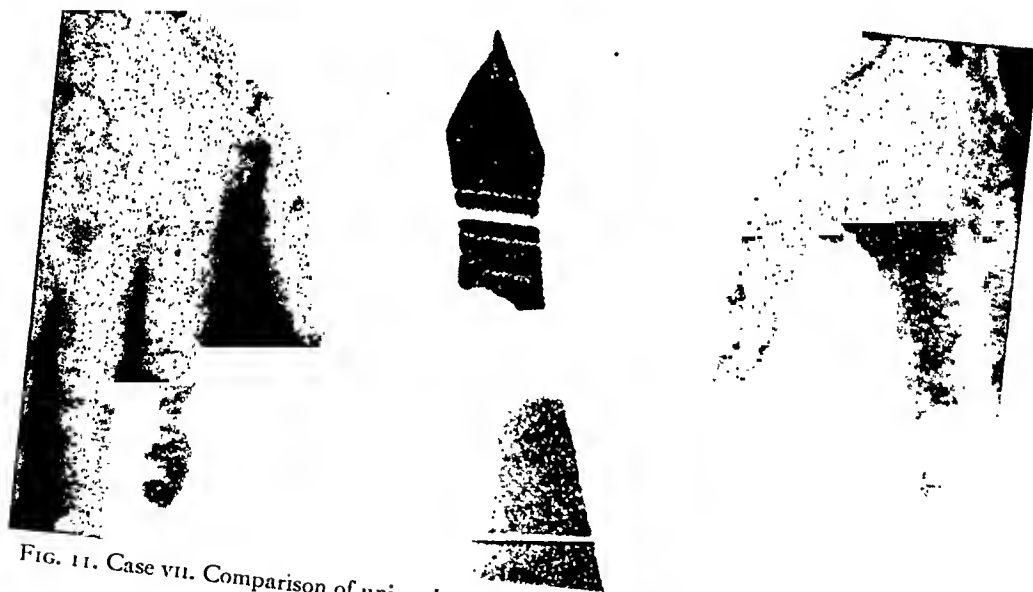


FIG. 11. Case VII. Comparison of uninvolved and grafted hands six months after operation.

sections showed no evidence of malignancy much to the surprise of the author.

**CASE VII. Malignant irradiation dermatitis of the hand:** A male patient, fifty-five years of age, received superficial x-irradiation for a fungus infection of the hand over a period of fifteen years. The first time the patient was observed he presented an area of extensive irradiation dermatitis involving most of the dorsum of the hand, with most marked changes on the radial side. There were several areas of superficial ulceration and one fairly deep ulcer

on the dorsum of the web space between the thumb and index finger. (Fig. 10.) The area of involved skin was excised and replaced with a thick dermatomic graft. After six months the grafted region was scarcely distinguishable from the normal skin on the uninvolved hand. (Fig. 11.) Microscopic sections of the skin removed showed changes typical of squamous cell carcinoma in the deeper ulcer. The prognosis is good.

**CASE VIII. Basal cell carcinoma in multiple irradiated areas on the face:** A male patient, thirty-



12

13

FIG. 12. Case VIII. Basal cell carcinoma of the chin and cheek in an area irradiated during the treatment of pigmented nevi thirty-three years before. A thoracic flap has been prepared to fill the defect after resection of the involved skin.

FIG. 13. Case VIII. Appearance of the same area shown in Figure 12 five years after resection and replacement by flap.

five years of age, received radium treatments in infancy for multiple congenital pigmented nevi. First seen in 1941, he presented multiple papillary excrescences and superficial ulceration in irradiated areas of the right temporal region and the left cheek over the body of the mandible. Biopsy confirmed the presence of basal cell carcinoma in both regions. The involved skin in both regions was widely resected. The defect in the right temporal region was replaced with a scalp flap while a delayed thoracic tube flap was employed to fill the defect on the left cheek. The appearance of the latter lesion before excision, with the thoracic tube prepared, is shown in Figure 12 and the completed flap in Figure 13. The original areas were free from recurrence five years later but new areas were beginning to appear in other treated regions of the face. From one of these, biopsy showed basal cell carcinoma.

**CASE IX. Basal cell carcinoma of the nose in region previously irradiated for lupus:** A male patient, fifty-eight years of age, received irradiation by x-ray for lupus of the nose and cheek thirty-five years before the date of first observation. At that time he presented an irregular ulcerative lesion of the left ala of the nose extending to

the septum and nasolabial fold. The involved skin was resected together with considerable surrounding skin, mucous membrane, septal cartilage and alar cartilages. The defect was immediately filled by means of a previously lined temporal artery flap. The resected ulcer proved to be a basal cell carcinoma which had involved the full thickness of the ala and margin of the septum. The nasal reconstruction was not entirely adequate from an esthetic standpoint but the patient was satisfied. He has remained free from recurrence for eight years.

**CASE X. Squamous cell carcinoma of the neck and cheek following irradiation for lupus:** A sixty-seven year old male patient received extensive x-irradiation for lupus of the face and neck over a period of twelve years prior to first observation by the author. At this time he presented a large, necrotic ulcer on the right side of the neck with a crater about 4 cm. in diameter. (Fig. 14.) The lesion was so painful that the patient had threatened suicide. It was apparent that the sternomastoid muscle and the deep cervical nodes were involved. The ulcer was widely resected together with the sternomastoid muscle, the internal jugular vein and the deep cervical nodes. The defect was filled by a flap swung from the back. Microscopic sec-



FIG. 14. Case x. Squamous cell carcinoma of the neck and cheek following irradiation for lupus. Radical resection was done and replacement with flap from back.

tions showed a moderately well differentiated squamous cell carcinoma in the ulcer and the deep cervical lymph nodes. Two years later a fungating lesion appeared on the cheek above the margin of the flap but not invading it. (Fig. 15.) This was widely resected and replaced with a temporal artery flap from the scalp. (Fig. 16.) Microscopic

sections showed squamous cell carcinoma. Ten years after the last operative procedure the patient was free from evidence of recurrence. (Fig. 17.) It is interesting to note that the skin flaps have in the meantime been extensively invaded by the lupus.

**CASE XI. Squamous cell carcinoma in irradiated keloids of both forearms:** The patient, a male sixty-three years old, had been severely burned eighteen years prior to our first observation. No skin grafts were done and he developed marked keloids and contracted scars involving the flexor aspects of both forearms and wrists. He was given an extensive course of x-irradiation to the keloids up to about six years prior to our observation. At the time of examination he showed flexion contractures of both wrists and large areas of irregular ulceration involving the flexor aspects of both forearms. (Fig. 18.) Biopsies showed both to contain well differentiated squamous cell carcinoma. The area on the right forearm was resected and replaced with a two-stage, broad-based abdominal flap. Because the flexor muscles and tendon sheaths of the left forearm were extensively involved with carcinoma it was necessary to amputate this arm. Bilateral axillary dissections were performed but no lymph nodes were involved by carcinoma. Five years later the patient was free from evidence of recurrence.

**Comment.** While free grafts are occasionally practical for replacement of irradiated skin which is the seat of an early carcinoma, pedicle grafts of full thickness skin and sub-



FIG. 15. Case x. Fungating recurrence in cheek adjacent to the flap margin two years after original resection.



FIG. 16. Case x. Appearance after resection of recurrence shown in Figure 15, and replacement of skin by means of a temporal artery scalp flap.

cutaneous tissue are usually more practical and probably safer in the long run. The author has been impressed on several occasions with the apparent resistance of flaps from other regions to recurrent cutaneous carcinoma. It seems likely that they are seldom if ever invaded by carcinoma. It is also an advantage at times to bring in a blood supply from a neighboring region to stimulate collateral circulation in the poorly vascularized bed. In this respect temporal artery flaps are particularly useful.

The prognosis of irradiation carcinoma of the skin should not be regarded as too serious, as illustrated by several cases reported. Radical surgical removal and replacement of skin provides protection for a period of years in most instances and when recurrences are encountered they still may be arrested or cured if treated as radically as the initial lesion.

It has been contended by many experienced surgeons that no attempts should be made to replace the skin resected because of malignancy at the time of the primary operation. Esthetic and economic conditions have often made it seem expedient to replace the damaged skin immediately with some type of graft and cure rates have not apparently been unfavorably influenced thereby.



FIG. 17. Case x. Appearance of the patient twelve years after initial resection. At the age of seventy-nine he is free from evident recurrence in spite of the fact that the lesion shown in Figure 14 had already invaded the deep cervical lymph nodes.



FIG. 18. Case XI. Squamous cell carcinoma of both forearms following irradiation of burn keloids. The area on the right forearm was resected and replaced with a broad-based abdominal flap. The left arm was amputated because the neoplasm had invaded the flexor muscles and tendons of the forearm. He remained free from recurrence five years after operation.

#### SUMMARY

The various types of skin injury following roentgen ray or radium treatment for a variety of conditions are reported. The resulting unfortunate sequelae range from acute burns to malignancy.

Illustrative case reports are given, together with the pathologic findings and the plastic repair.

Worthy of note are the long interval between

the original treatment and the development of malignant change and the types of carcinoma found at operation.

A report of the unfavorable results of irradiation which inevitably seek out the plastic surgeon should not discourage the use of this powerful agency under proper conditions and for proper indications. It is suggested, however, that its use in the treatment of benign conditions which can be handled effectively by other means might be curtailed.





# TRACTION SPLINT FOR HAND AND FINGERS

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IN 1924, a young man was sent to me with comminuted fractures of the second, third, fourth and fifth metacarpal bones of the right hand. The second was compounded on the dorsum of the hand where there was a granulating wound 2 inches long. The patient received his injuries several days before, as I recall it, in a fall from an oil derrick in a western oil field. The wound had been treated and left open but little attempt at splinting had been made.

His history had been lost but his x-ray films were preserved and are reproduced in this paper. He was a graduate of Annapolis with a promising future and I felt keenly the responsibility of restoring his right hand to as good a function as might be attained.

I was impressed at that time and still am with the inadequate degree of traction which is manifested by the relatively short elastic bands used in the different types of so-called banjo splints, for the following reason: When any form of traction using a weight or a weight acting over a pulley is used, the pull is constantly of the same degree. This does not occur when elastic traction is used. If the material used to institute traction is short, it is obvious that any small degree of shortening between its two ends will effect the efficiency of the pull. The reason is that with any given elastic material the elongation is proportional to the tension applied, provided the elastic limit is not exceeded, or for any given elastic device the greater the possible elongation the greater is the back and forth motion without loss of effective tension. Stated in another way, the range of motion throughout at which effective tension can be maintained is directly proportional to the length of the elastic member. With these facts in mind the short elastic bands used in the so-called banjo splints have always seemed to me to be lacking in efficiency. The turnbuckle devices seen on some of these would appear to bear out this impression.

I devised this splint and applied it with skin traction using a technic from which I have not departed nor found wanting. Variations of it will be mentioned later. The materials used

were a  $\frac{3}{16}$  inch basswood splint, a piece of  $\frac{1}{8}$  inch Bessemer steel rod, four small brass pulley shives with central holes fitting easily over the Bessemer steel rod and four brass springs used for hanging curtains (bought in the five and ten cent store). The pieces of wire used were cut from ordinary 2 inch brass safety pins.

The splint is constructed as follows: The splint wood is cut roughly to fit the forearm with its distal end shaped as in Figure 1. The lateral edges of this distal portion are cut out and a shallow groove cut in the two edges leaving the shoulder at the proximal end for the ends of the rod to butt against. The required number of shives are threaded onto the rod, one for each finger to be put in traction. The rod is bent with sharp angles to avoid the shives jamming on the curves. The length of the side pieces of the rod should be measured from the shoulder in the proximal end of the grooved edge to 5 inches or more beyond the end of the wood splint. One must allow enough room between the ends of the fingers when in traction and the pulley shives to avoid them touching and preventing traction. The bent rod is attached to the wood splint by laying its ends in the grooves butting against the shoulders cut to receive them. These are then held in place by winding two or three layers of wide adhesive plaster about this end of the splint and rod ends. The rectangular distal end of the splint is used to build up a support to preserve the palmar arches and curve of the hand. Traction is secured by gluing strips of muslin with Ambroid Canoe glue\* on the indicated fingers. A strip of muslin is cut wide enough to extend a little less than half around the finger and a little longer than the combined length of the area to be used for traction on the dorsal and volar surfaces of the fingers. The edges of the strip should not be so wide as to meet and completely surround the fingers in order to allow for swelling. This may extend up onto the hand in metacarpal injuries. A small longitudinal slit is cut in the center of the muslin strip half

\* Ambroid Canoe glue can be obtained at any hardware store.

# SPLINT FOR FINGER AND METACARPAL TRACTION

## USING TEN CENT SPRING CURTAIN ROD - ADJUSTABLE PULL

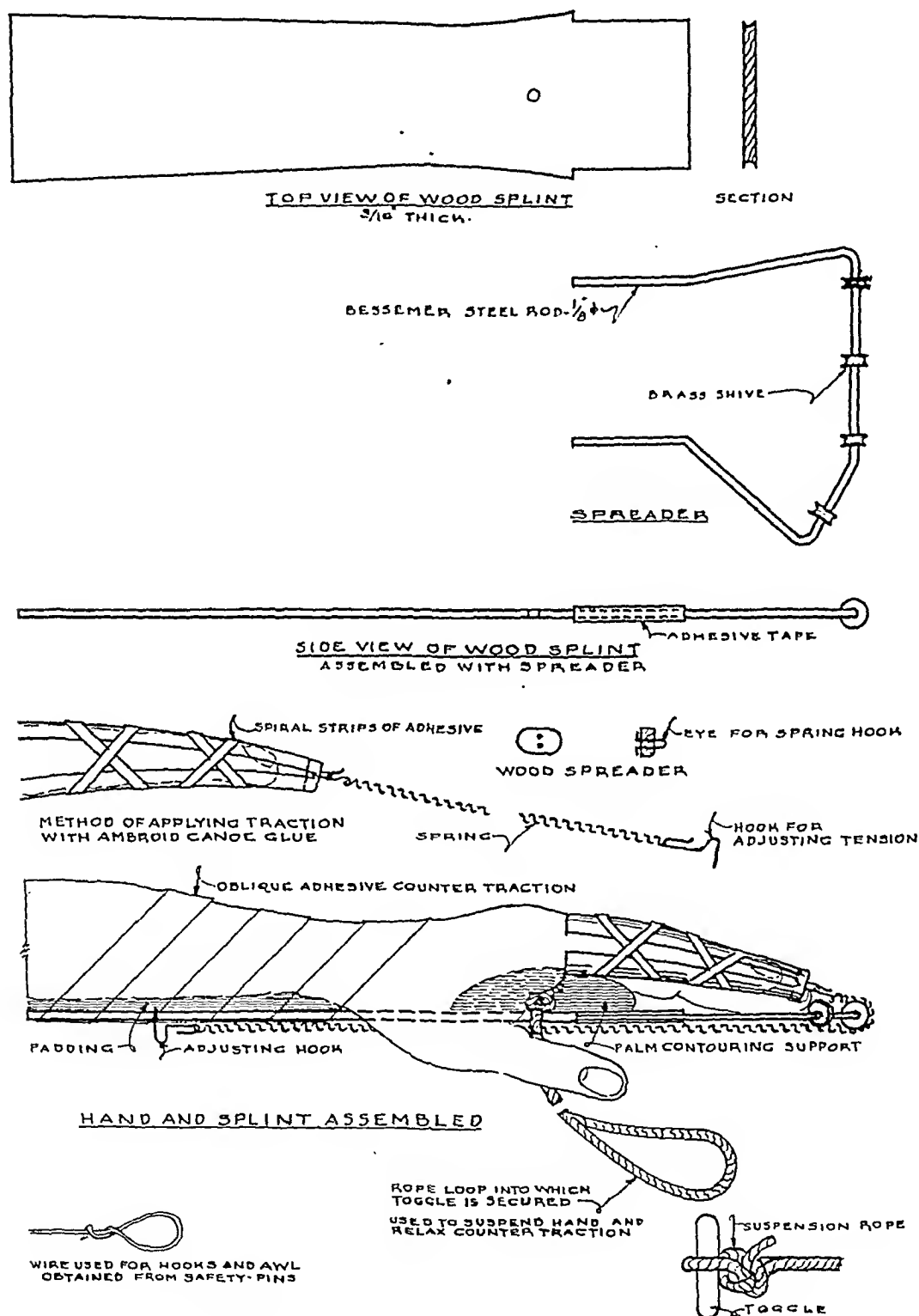


FIG. 1. Detailed drawing to show construction and application of splint.

way between its two ends to receive the small wire loop of the specially shaped spreader. The strips are then placed on a piece of paper and the glue spread quickly on each piece just before the strip is applied. The spreader is placed in position and the strip applied to the dorsum and volar surface of the finger which is immediately bandaged with a few turns of a gauze finger bandage for a good contact of the glue. This bandage is cut off as soon as the glue dries which will be well set in half an hour. Each strip should be applied separately as the glue dries quickly. When the requisite number of fingers have been prepared, the forearm is shaved of hair and the surface of the splint is well padded with cotton batting or wadding, *not with sheet wadding*. This is laid on the splint but not bandaged on.

The splint is then applied to the anterior surface of the forearm with the distal end of the wood reaching to the middle of the proximal phalanx at the interdigital web. The splint is held to the forearm with adhesive plaster strips  $1\frac{1}{2}$  inches wide overlapping each other, and extending from wrist to the upper end of the splint where the tape is passed over the splint's end to prevent it slipping upward when supporting countertraction. These adhesive strips are put on obliquely extending from the splint downward and posteriorly. This is absolutely necessary, as at night when the hand is hung up by the device arranged for doing so, the obliquity of the strips become less so as the splint is pulled upon, and lymphatic return and circulation is not interfered with by a constrictive dressing. One complete turn of the spring coil at one end of the long spring is opened up with pliers to form a hook which is hooked into the wire loop in the spreader. The traction spring is then brought over the pulley shive and measured upon the undersurface of the splint to about its middle. It is then cut off with pliers and a couple of loops turned down to engage the hook which is used to lock it to the splint. A longitudinal line of holes is made from this point with a small awl shown in Figure 1 constructed from the same safety pin wire as the hook, a  $\frac{1}{4}$  to  $\frac{1}{2}$  inch apart extending upward and downward. Tension on the spring is made by placing the free arm of the hook in such a hole as will afford the desired degree of traction. This hook can be and should be put on the maximum tension at first. The surgeon or the patient under his direction can

change the degree of tension from time to time as might be indicated.

It is well to call attention here to the fact that a given area of skin will tolerate only a certain amount of pull. Ambroid glue will not slip or irritate the skin, but if a tension is made in excess of the tolerance of the skin area used, blebs will appear at the proximal end of the traction strips or near an extensive fracture of the metacarpals. Excessive pull may determine blebbing. These blebs are best treated by a double or triple strength calamine lotion (without carbolic) and diminishing the degree of traction by changing the position of the hook.

An important feature will be noted in Figure 1. In the wood splint there is a hole which should come under the concavity of the palm. I pass the end of a piece of hatter's cord or a line strong enough to support the weight of the upper limb off the bed when the patient is resting in bed, and tie a big knot in the end so that it will not pull out of the hole. On the free end a loop is tied about three inches long, and this line should be long enough to have this loop and knot extend beyond the pulley shives. The purpose of this arrangement is, that when the patient is in bed at night a stout line is tied to a picture hook which is hooked on the moulding or tied to an elevated object; the lower free end of the line has a small piece of wood tied to its middle. The line is of such a length that when the loop is passed over the wooden toggle and is supported by this line, the elbow is off the bed. This puts a pull on the whole traction and releases the constriction of the adhesive encircling the forearm and definitely increases the degree of traction, which must be kept in mind. This elevation and relief of constriction at night has a most definite effect in lessening the degree of swelling acquired in the day time and diminishes the tendency of periarticular fibrosis about the finger joints.

To preserve the concave palmar arches, I have used felt pads in cold weather, and in hot weather a flattened roll of copper fly screen, the edges of which are taped with adhesive plaster. I use a simple gauze bandage loosely applied to cover all. My patients have used lengths of stocking with holes cut for the thumb or such fingers as are not in traction to permit functioning. I like to apply traction to a less degree on additional fingers lateral or on both sides of the injured one to preserve the alignment and for clinical checking.

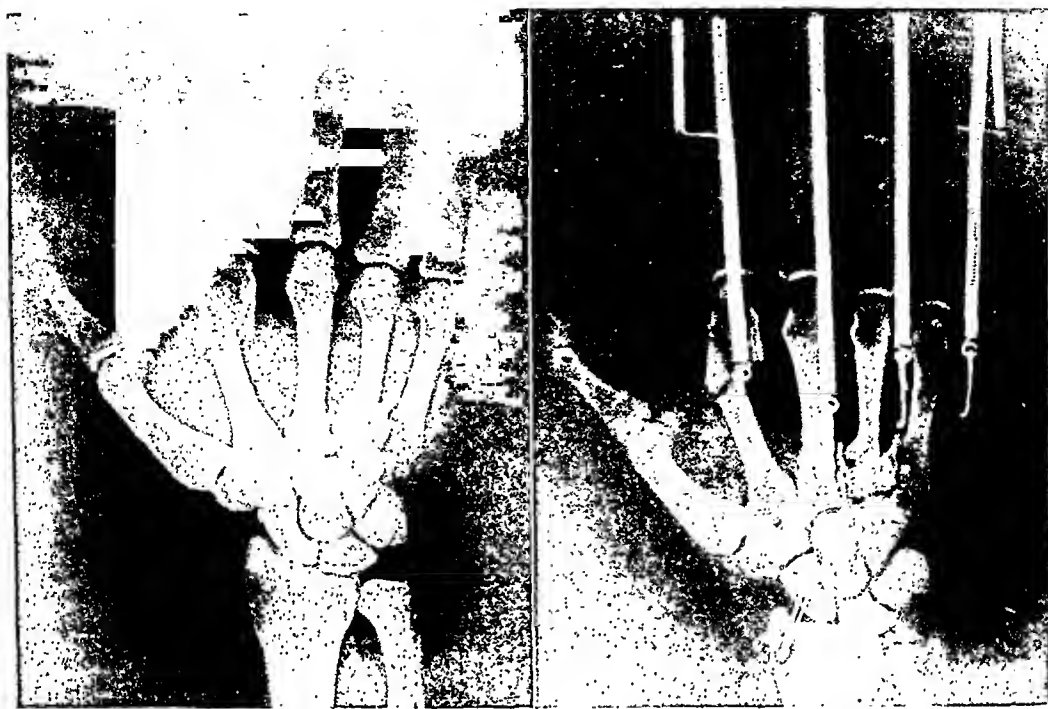


FIG. 2. Film showing anteroposterior view of hand before traction.

FIG. 3. Film showing anteroposterior view of hand with traction.

After the gauze bandage, which is put on to ensure good glue contact, has been cut off, I apply narrow adhesive strips in a long spiral up the fingers to maintain contact of the edges of the traction strips.

The wood splint and wire extension can be designed for traction of two or more fingers, allowing limited use of the free fingers and thumb. In the illustration, I have shown how the thumb can be held in abduction by the pulley arrangement. To prevent the pulleys from sliding laterally from a desired position, small bushings can be built up on each side of them with narrow adhesive strips.

The spreader is shaped from a portion of the same wood as is used in the splint. Its oval shape prevents lifting the traction strips from the end of the finger and especially compressing the finger tip with its resulting discomfort. Its contour should roughly coincide with a cross section of the finger at about  $\frac{1}{4}$  inch from the tip. The two holes are drilled with a drill made from the safety pin wire. A U-shaped piece of the wire is put through these and the ends turned over leaving the loop as shown, which is placed through the opening cut in the traction strip before applying, and to which the hook on the end of the spring is attached. The adjusting hooks on which the traction depends must be

made so that the right angle portion which enters the wood must fit the hole snugly and be at a correct right angle, otherwise the hooks will pull out. They should not be long enough to extend so far through the splint as to penetrate the padding. To hold the hooks in place, a piece of adhesive laid over them and extending up on the sides will prevent their slipping out. Soaping the awl will facilitate penetrating the adhesive.

If blebs form at the proximal end of the traction strips, usually on the dorsum, the strip end can be lifted by using acetone on a pledget of cotton and by removing the end for a short distance to determine the extent of the blister, then Calamine may be applied. The strips can be extended proximally onto the palm and dorsum of the hand.

Although it takes time to make and apply this splint, it is the most efficient ambulatory finger and metacarpal traction device I know of. One is well repaid for the time taken to make and apply it for the comfort it affords the patient and the satisfactory result. The thing I would emphasize about the splint is the efficiency of a long spring or elastic traction member and the simplicity of adjusting the same. The springs I bought in 1918 and until

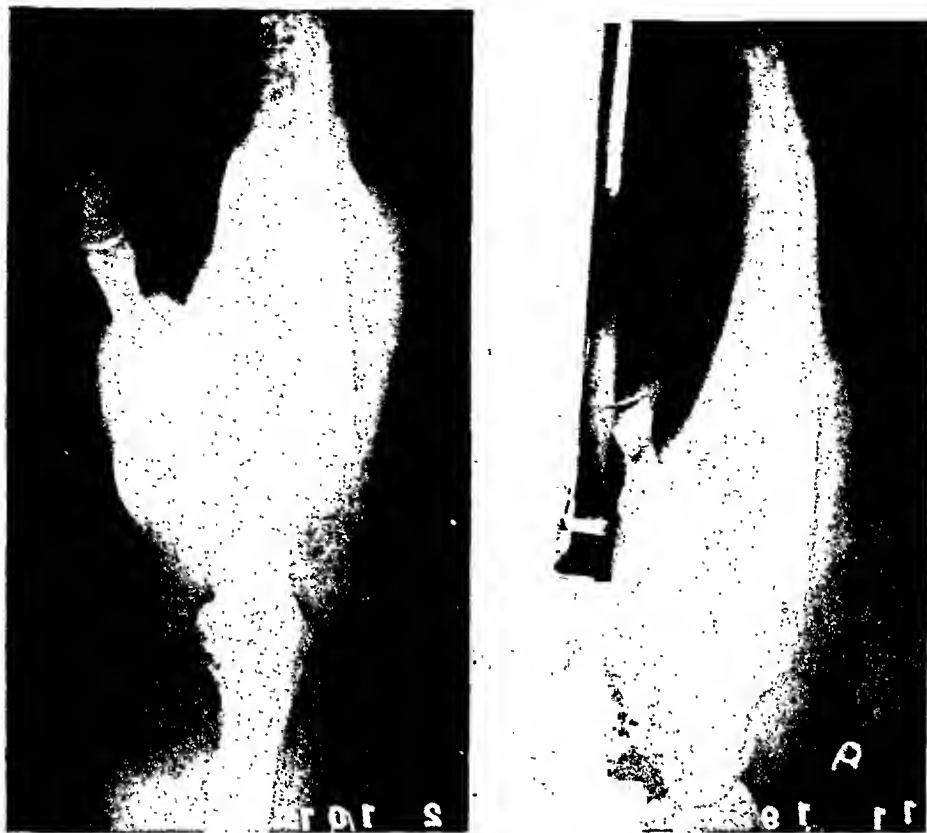


FIG. 4. Film showing lateral view of hand before traction.  
 FIG. 5. Film showing lateral view of hand with traction.

the war were not as stiff as the one's I have been able to secure since the war.

I have made a splint substituting sheet aluminum for the wooden portion, but I have not used it as it does not readily lend itself to traction to less than four fingers.

I have not felt the need of using a plaster cast about the forearm. It has obvious difficulties in affixing the bar supporting pulleys and in arranging for tension hooks. However, such arrangement is not precluded.

For traction with the fingers flexed, a cross bar under the palmar portion would be called for to pass the spring over to make the direction of the spring conform to the angle created by bending the shive supporting member. If enough traction cannot be supported by the skin area for fractures of proximal and middle phalanges, threaded wires can be used in the terminal phalanx with a suitable tractor loop. The threads prevent side slipping of the wire in the bone and on the loop hooks.



# DIAGNOSIS OF CLOSTRIDIAL MYOSITIS\*

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MANY of our greatest advancements in surgery have had their inception in the experimental laboratory, while others have been achieved through astute clinical observations. Anaerobic gas infection has benefited from both endeavors.

Although recognized as a distinct surgical entity prior to World War I, its high incidence<sup>1</sup> on the Western Front provided an unusual opportunity for clinical observations and study, which contributed much to our understanding of this infection.

In the years which intervened between World War I and World War II, further experimental and clinical investigation aided considerably in crystallizing our knowledge of clostridial infections. However, through all of this, one outstanding error in our concept persisted: Most of us continued to regard all suspiciously infected wounds, from which clostridia were recovered as incipient or established gas gangrene. Furthermore, if in addition to the finding of clostridia, clinical gas production was apparent, and a foul putrefactive odor was detected, we were positive that gas gangrene was present. In other words, we failed to recognize first, that clostridial organisms may be frequently recovered from infected or even clinically clean traumatic wounds, yet, seldom interfere with normal wound repair;<sup>2</sup> and secondly, that a foul smelling wound with extensive gas in the subcutaneous and fascial planes is most often not true "gas gangrene," but its relatively benign cousin "anaerobic cellulitis."

The recent war again provided us a golden opportunity to extend our knowledge in clostridial infections. Despite this improved knowledge considerable confusion still exists as to just what constitutes a *clostridial myositis* and what constitutes an *anaerobic cellulitis*. The fallacy of statistics regarding pathology, prognosis and methods of treatment when we have failed to recognize, and differentiate these two clostridial infections is at once appreciated. The latter calls for thorough yet conservative treatment, whereas clostridial myositis demands prompt, energetic and radical treatment.

## DEFINITION

*Clostridial myositis* (gas gangrene) is clinically a very rapid, invasive involvement of muscle, associated with severe toxemia, moderate fever, rapid pulse, apprehension, delirium, a rapidly developing anemia and a reduced blood volume. Localized pain is often the first symptom, but frequently a sense of heaviness in the involved extremity, or a rise in the pulse rate, with a slight increase in temperature, will give a clue to the presence of infection before pain is mentioned.

*Anaerobic cellulitis or fasciitis* (gas abscess), on the other hand is a relatively benign clostridial infection, which, however, more clearly fulfills our preconceived ideas of "gas gangrene" than does true clostridial myositis itself. This is due mainly to the almost constant presence of gas, crepitation and foul acrid discharge, which we have always considered synonymous with "gas gangrene." This infection involves the subcutaneous tissues and the fascia between the muscle groups but *never* the muscle bundles, except those which have been traumatized in the immediate vicinity of the wound. Toxemia, with mental symptoms, hypotension and anemia are conspicuously absent, unless due to the associated injury. Severe localized pain is almost never a symptom.

*Anaerobic streptococcal myositis* is very rarely encountered. Its onset is insidious and is associated with swelling, edema and discoloration around the site of injury, which extends diffusely.<sup>3,4,5</sup> As this increases, pain begins and becomes rapidly severe. The pulse and temperature may be quite high and associated with a mild delirium. Locally, the wound is wet, foul smelling, discharging a profuse thin, blood stained seropurulent material. The muscle involvement is focal rather than diffuse. Early, circumscribed areas of firm, pale muscle have been noted<sup>6</sup> which later became whitish-gray, then began to liquefy, coalesce and form a small amount of gas.

Treatment of this infection must be prompt and energetic. Relaxing incisions, including

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wide resection of all involved muscle and connective tissue with adequate drainage is mandatory.

#### ETIOLOGY

It is now an established fact that many traumatic wounds (50 to 60 per cent) may be contaminated with *Clostridia*<sup>7</sup> yet only a very small percentage of these wounds (1 to 2 per cent) ever show any clinical evidence of a clostridial infection. Therefore other factors, in addition to the presence of these anaerobes, are usually present before a clinical anaerobic infection will develop. In general, one may state that the presence of clostridial organisms, plus excessively damaged necrotic, or avascular tissue, particularly muscle and blood clot, appears to be essential for the development of clostridial myositis. Just why only a small percentage of the wounds in which these conditions exist, develop anaerobic infections is not entirely clear. Our experience in the recent war, however, has established certain facts of etiologic importance, which very definitely favor the development of a clostridial myositis.

These etiologic factors in the probable order of their importance are: (1) major vascular injury; (2) compound fractures; (3) prolonged time interval between wounding and treatment; (4) wounds contaminated with manured soil; (5) thigh and buttock wounds; (6) severe wounds, with marked tissue destruction, and (7) wounds contaminated with woolen clothing. There are numerous other less specific etiologic factors which might be considered, such as the state of nutrition at the time of wounding, the amount of associated hemorrhage, with prolonged shock and reduced blood volume, and the weather, which if cold, may have contributed to prolonged chilling, ischemia and anoxia of all body tissues.

It should be emphasized that these etiologic factors which we have enumerated are not hypothetical figments of imagination, but are real, definite, absolute factors, established by statistical experience. Thus Power<sup>8</sup> and North<sup>9</sup> have stressed the almost certainty of gas gangrene developing in devascularized muscle contaminated with *Clostridia*. Of 108 amputations which we, of the 2nd Auxiliary Surgical Group, did because of an anaerobic infection, there were only eleven in which vascular injury was not present.<sup>10</sup> Furthermore, it has been stated<sup>6,11,12</sup> that 60 to 75 per cent of clostridial

infections are associated with compound fractures; yet based on final statistics of World War I,<sup>13</sup> compound fractures are present only in approximately one-sixth or 17 per cent of the total number of battle casualties.

In our opinion a constant awareness of these established etiologic factors is essential to an early diagnosis.

#### DIAGNOSIS

It appears pertinent that we again re-emphasize that the mere detection of *Clostridia* in a wound is not of great significance. It has long been known that these organisms may be present without giving rise to clinically recognizable infection.<sup>2</sup>

The rapid identification technic recently proposed by Butler<sup>14</sup> in *Clostridium welchii* infections offers hope that the problem of diagnosis may be much simplified. The degree of capsulation of the organisms, together with the extent of damage to leukocytes, as revealed in specially stained direct smears, provides her with a reliable index of the severity of the infection. Thus, heavy capsulation, with damage to leukocytes, points to an actively invasive infection (clostridial myositis). Conversely, poor capsulation, active phagocytosis and lack of leukocyte damage, all indicate that a severe invasive infection is unlikely. These observations certainly warrant further study.

In our experience the diagnosis of *clostridial myositis* was definitely *clinical* and not *bacteriological*.

The necessity of relying almost exclusively upon clinical appraisal prompted us to establish some diagnostic criteria. Although quite elastic, and certainly when considered individually—not infallible—these criteria were found quite helpful, not only in establishing the diagnosis of a clostridial infection but also in making a clear cut differential diagnosis. (Table 1.) These criteria in the probable order of their significance are as follows:

1. *Toxemia*. This is one of the most prominent and constant features in *clostridial myositis*. The mental symptoms in the early case may be manifested only by a bright-eyed alertness or overanxiety for personal welfare. In the more advanced or fulminating infection, the patient may be quite euphoric and excitable, or there may be apathy, drowsiness and delirium. In *anaerobic cellulitis* toxemia is conspicuous by its



absence and thereby constitutes one of our most important points of differentiation.

2. *Pain.* This is often very severe at the site of injury. One might expect that these patients, with severe complicated wounds, should have considerable pain. But, such is not the

this rather constant finding is not too well understood. However, since shock and reduced circulating blood volume<sup>12</sup> are intimately associated with the toxemia of *clostridial myositis*, we may assume that the hypotension is a measure of the degree of shock and oligemia present.

TABLE I  
ANAEROBIC GAS INFECTIONS--DIAGNOSTIC CRITERIA

	Clostridial Myositis	Anaerobic Cellulitis-Fasciitis	Anaerobic Strept. Myositis
Toxemia	Constant	Absent	Mild, varies with temperature
Pain	Often present, severe	Absent	Often present, severe
Pulse	High—poor quality	Proportionate to temperature; good quality	High—proportionate to temperature
Anemia	Usually present	Absent	Not characteristic
Blood pressure	Low	Normal	Normal
Temperature	100° to 102° F.	101° to 103° F.	High
Wound			
(1) Discharge	Varies—slight watery to profuse brown	Profuse, brownish seropurulent	Wet, edematous, profuse, blood-stained, seropurulent
(2) Odor	Inconstant	Constant, foul putrefactive	Foul
(3) Crepitation	Inconstant	Constant, extensive	Slight, late
(4) Muscle	Always involved—diffuse	Never involved—except adjacent to wound	Usually involved but focal

case, especially if their injury is immobilized. Therefore, the development of severe pain at the site of injury is a most significant symptom. Occasionally, patients may complain of a sense of weight, heaviness or lightness in the wounded extremity before the onset of pain. In *anaerobic cellulitis*, pain is usually absent, but if present, is mild in character.

3. *High Pulse Rate.* A pulse rate, usually over 120, and out of proportion to the degree of infection or temperature is usually present. As the infection increases, the pulse rate becomes more rapid and of poor quality. In *anaerobic cellulitis*, the pulse rate may be elevated, but it generally follows the temperature curve, and is of good quality.

4. *Anemia.* This condition is almost always present and varies with the length of the infection and the degree of toxemia. It is not unusual to encounter total red cell counts under 1.5 to 2 million. This anemia is said<sup>16</sup> to be due to the enzyme lecithinase, present in the alpha toxin of *Clostridium welchii*, which rapidly breaks down the outer lipid membranes of erythrocytes and other cells, causing hemolysis and cell destruction. Anemia is not a characteristic finding in *anaerobic cellulitis*.

5. *Hypotension.* The exact mechanism of

In *anaerobic cellulitis* we have never noted hypotension, shock or an alarming oligemia.

6. *Temperature Elevation.* The significance of this lies in the fact that it is rarely over 100° to 102° F., whereas the extent of the infection, and the rapid pulse rate, indicate that the temperature should be much higher. In *anaerobic cellulitis*, the temperature may vary from 101° to 103° F. It closely parallels the pulse rate and degree of sepsis present.

7. *Wound.* Ordinarily, *clostridial myositis* is not a single bacterial infection, but a combination of several *Clostridia* with *Clostridium welchii* predominating. Examination of the wound early in the infection may reveal only a slight edema associated with a thin, watery discharge. Rather extreme tenderness is usually present. Gas is never a prominent feature and at this stage is often absent. In a similar wound, a few hours later the edema will be more marked, there will be more discharge and possibly a few bubbles of gas may be expressed on pressure.

Unfortunately, the infection is often much more advanced before it is seen by the surgeon. Then, the extremity may be found swollen, livid or mottled, and as a rule, quite painful. There may be a profuse serous or serosanguine-

ous discharge from the wound which has saturated the dressing. This may have a peculiar sweetish odor or it may be pungent, foul and putrefactive. Still later, the discharge may turn into a dirty brown color. On the other hand, there may be virtually no discharge; and if muscle is exposed, it may appear dry and dull. Some surgeons insist that there is a characteristic odor to gas gangrene which is quite diagnostic. In our experience neither the odor of the wound or crepitation have been reliable signs.

However, it is the local appearance of the involved muscle, which is the most constant and characteristic feature of *clostridial myositis*. This may vary from a salmon pink or brick red to a dirty, gray slate color, and in extreme cases<sup>16</sup> it will appear black and diffuent. Should any doubt exist as to their involvement, it is well to keep in mind that clostridial infected muscle does not contract or bleed when cut.

Let us now summarize for the sake of simplicity this discussion on the wound as follows: (1) *Discharge* may vary from a slight watery or dirty brown to very profuse and serosanguineous; (2) *odor* is inconstant, varies with the secondary wound invaders. If present, it is usually putrid or decayed meat in character; (3) *crepitation* is not a reliable sign; it is often absent until late in the infection. If present, it may be detected by varying pressure with a stethoscope before it can be palpated with the fingers.

The local findings in *anaerobic cellulitis* are so characteristic that a differential diagnosis may be made without difficulty. MacLennan<sup>3</sup> describes it as a dirty wound, with a foul odor and a moderately profuse, brownish seropurulent discharge. Jergesen<sup>6</sup> has noted that not infrequently the wound is lined with a slaggy-grayish-white diphtheritic membrane, which when cut away reveals normal, healthy, bleeding, contractile muscles. Gas is *always* present and abundant. It is found involving and extending diffusely in the fascia between muscle groups, crackling in the subcutaneous tissue and bubbling up through the foul, putrid wound discharge. Thus its presence, when extensive, and in the absence of a pronounced toxemia is very important in differential diagnosis.

The treatment of anaerobic cellulitis while conservative should nevertheless be prompt. It is essentially surgical, consisting of relief of tension, excision of necrotic and grossly infected tissue and the establishment of adequate drainage.

With these criteria, as well as our etiologic factors in mind, a diagnosis of *clostridial myositis* may be conveniently developed around two general groups: (1) Infection anticipated, beginning or established in the untreated wound, and (2) infection developing in the postoperative or débrided wound.

Especially in group 1, the importance of a careful history in developing a diagnosis cannot be overemphasized. The "time lag" is particularly important. The potentialities of a contaminated wound incurred in a barnyard as against one incurred on a paved highway are considered. A history of previous hemorrhage, necessitating the prolonged application of a tourniquet, a mental note of the type and soiled condition of the patients' clothing, the location of the wound, and the presence of an associated vascular injury or compound fracture, all contribute to our local and general evaluation of anticipated findings.

An evaluation of these potential etiologic factors when added to a carefully applied analysis of our diagnostic criteria, place in our possession, maximum presumptive evidence, either for or against a *clostridial myositis*, even before we have inspected the wound. This is not a drawn out, time consuming procedure; with the possible exception of the blood count, it can all be accomplished within a few minutes while resuscitative measures are being initiated. If the diagnosis is reasonably certain, wound inspection may be deferred until the patient is under anesthesia on the operating table. This has been our usual policy. However, if any doubt exists, a definite diagnosis can be made in most instances after inspection.

X-rays can be of definite diagnostic value in this infection. Occasionally, in a penetrating wound with a small wound of entrance, the first indication of a *clostridial myositis* will be the finding of a few bubbles of gas in the region of the foreign body on the x-ray film. In general, however, the finding of gas in the soft tissues should be accepted with reservations. Gas bubbles are not only present in an anaerobic cellulitis<sup>11</sup> but the nature of the wound occasionally allows air to enter its depths. Muscle fibers, which are cut suddenly by a sharp fragment, will spring apart, and may aspirate air through the skin wound into the gap.<sup>16</sup> In the absence of one or more of our diagnostic criteria, either of the latter two conditions should be considered.

Group 2 infections (occurring in a débrided

wound) are most unfortunate and should not occur, but they do and with distressing frequency. We must remember, however, that débridement is not the ideally aseptic excision en masse procedure, which is employed in removing a malignant growth. Débridement is an operation of incision and excision in which the surgery is accomplished almost entirely from within a potentially contaminated if not already infected tract. Furthermore, many wounds, because of their proximity to vital structures, such as major nerves and blood vessels, do not lend themselves well to a complete débridement. It is, therefore, inescapable that some organisms, a small blood clot, or a piece of devitalized muscle may, in some instances be left behind.

Thus, with the knowledge that *clostridial myositis* may develop in spite of prophylactic débridement, chemotherapy and antitoxin, an attitude of observant alertness should be adopted by everyone who has contact with these postoperative patients. The onset of this infection is characteristically acute and fulminating, the toxemia severe and rapidly progressive.

If etiologic factors favor a high expected incidence of anaerobic infections, it should be highly desirable for the surgeon to instruct his day and night nurses and ward attendants in the practical application of our formulated diagnostic criteria. Thus the busy surgeon's attention might be directed to an infection in its incipency. An increase in the pulse rate, out of proportion to the temperature, is an indication for investigation. The development of local pain or undue apprehension should require the surgeon's attention and not be relieved with a blanket order for another hypodermic, by an overly busy, or too sympathetic nurse. We trust that the alert surgeon will never wait for the "odor" or the development of edema and crepitation, outside the limits of the dressing.

#### CONCLUSION

In conclusion we wish to direct attention to several points:

1. Our experience indicates that *clostridial* infections fall into three separate and distinct clinical types, depending upon the inherent invasive characteristics of the *clostridial* organisms responsible for the infection. First, that type of *clostridial myositis* or true gas gangrene, which is so highly invasive, that it will attack,

invade and destroy undamaged tissue. This type is not common. Second, that type of *clostridial myositis*, which is less invasive, but does spread in devascularized and traumatized muscle. It is usually localized to one muscle or muscle group, and is attended with less shock and toxemia than the first type. However, if neglected, the action of its toxins on adjacent tissue, will be sufficient to permit spread in previously healthy muscle. Third, anaerobic cellulitis or fasciitis, the characteristics of which we have previously mentioned.

2. Although *clostridial* infection is generally regarded as a complication associated with the trauma of war, it is also a complication which occurs too frequently in civilian wounds.

3. It is apparent that we have been leaning too heavily on chemotherapy, to compensate for needless time lags and incomplete, minimal débridements.

4. The diagnosis of *clostridial* infection at present is definitely clinical and not bacteriological. Many contaminated wounds contain *Clostridia*, yet experience has shown that in very few of these, a recognizable *clostridial* infection develops.

5. The importance of differentiating between a *clostridial myositis*, or true "gas gangrene" and an anaerobic cellulitis, or fasciitis, cannot be over stressed. The fallacy of statistics regarding pathology, prognosis, mortality and methods of treatment, when we have failed to recognize and differentiate these two *clostridial* infections, is at once appreciated.

#### SUMMARY

1. Certain etiologic factors have been established, which if constantly borne in mind, will make the surgeon so alert to an impending *clostridial* infection, that early diagnosis and prompt energetic treatment will be accomplished before the infection has had an opportunity to become firmly established.

2. These etiological factors, which favor *clostridial* infection are: (1) major vascular injury; (2) compound fractures; (3) prolonged time lag; (4) wounds contaminated with manured soil; (5) thigh and buttock wounds; (6) wounds with marked tissue destruction and (7) wounds contaminated with woolen clothing.

3. Certain diagnostic criteria have been established which will not only aid in establishing a diagnosis of *clostridial myositis*, but will also

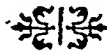
aid in differentiating it from the relatively benign clostridial infection anaerobic cellulitis.

4. These criteria are: (1) toxemia or shock or both; (2) pain at the site of injury; (3) high pulse rate, out of proportion to the temperature; (4) anemia (1.5 to 2 million); (5) hypotension; (6) moderate temperature, 100° to 102°F. and (7) muscle involvement, which does not bleed or contract when cut. The discharge, odor and crepitation are inconstant and unreliable signs in clostridial myositis.

Although the recent war has provided an opportunity for an improved knowledge of these infections, the problem has not as yet been satisfactorily solved. It is our earnest hope that laboratory and clinical investigation will be relentlessly continued, so that in the event of another war, we may better cope with this deadly complication of traumatic wounds.

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# REPAIR OF MAJOR TENDON RUPTURES BY BURIED REMOVABLE SUTURE\*

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ALL large tendon ruptures are difficult surgical problems. The rupture takes place through unhealthy, degenerated and avascular tendon tissues. In the process of rupturing these tissues become extensively shredded and lacerated so that clean cut, viable fragment ends suitable for primary suture, such as may be expected in an incised wound through a tendon, are not present. The extent of the injury to the tendon and its associated structures as well as the accompanying local tissue reaction is severe. The associated muscle components are among the strongest in the body so that marked retraction of the proximal tendon fragment is the rule and these muscle forces must be overcome and controlled before restoration and maintenance of anatomy can be accomplished. When the lesion is of weeks' or months' duration, as is not infrequently the case, extensive cicatrization of the whole local area and a relatively fixed contracture of the retracting musculature makes the treatment problem still more difficult. In all cases, even after surgical repair has been accomplished successfully, the normal functional demand which ambulation places upon the major tendons of the lower extremity has made maintenance of function throughout the healing period difficult to accomplish without seriously jeopardizing the integrity of the suture line.

It has been common practice in repairing large tendon ruptures to pull the retracted proximal fragment as far distalward as possible and to bring the distal fragment as far proximally as it would come by some combination of manual traction and posture of the injured extremity. By this mechanism, and utilizing all of the shredded and lacerated tendon ends for suture purposes some sort of repair usually was accomplished. A surgically satisfactory repair rarely, if ever, was obtained. More often than not the suture line was precarious

enough so that reinforcement and bridging of the imperfectly closed gap between the fragment ends by a free fascial graft or some heavy suture material was required before the repair would hold. Postoperative immobilization usually was mandatory. Often, especially following repair of the tendo achillis, it was necessary to apply the immobilization in the poorest possible functional position. Continued function of the extremity during the healing period rarely was possible and the penalties of disuse and immobilization were inevitable and severe.

This treatment program has produced results that left much to be desired. The absence of any well documented end result reports in the literature suggests that most surgeons have not enjoyed conspicuous success in repairing these lesions. Logical evaluation of the problem in the light of basic surgical principles and the known physiology of tissue healing makes it clear that the best results cannot be expected following any such regimen which violates every principle of surgical repair and the management of damaged motor-skeletal structures. The optimum result following tendon repair requires accurate and snug apposition of healthy to healthy tissue without tension at the repair site, with a minimum of foreign material (whether suture material, fascia or dead tendon fibers) at the healing site and a maximum maintenance of function throughout the healing period. Major tendon repair has in the past been characterized by inaccurate and incomplete apposition of avascular and degenerated tendon ends under considerable tension by means of many sutures, various forms of reinforcement and a postoperative program which abolished function throughout the healing period. Therapy of this type is irreconcilable with good results.

It has been pointed out in a previous report<sup>2</sup> that accurate and snug apposition of healthy to healthy tendon tissue with a minimum of

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tension on the repair and a minimum of foreign material in the healing site can be most nearly accomplished by means of the ingenious removable traction suture evolved by Bunnell<sup>1</sup> for the management of tendon injuries in the hand. His contention that the removable suture principle was applicable to the repair of other tendons suggested a method for improving the results in major tendon lesions and stimulated development of the technic to be described. Some modifications of his technic were necessary. The presence of wires emerging through the skin coincident with motion of the part over a period of weeks would constitute a constant potential risk of infection. The retractile force of the muscles to be neutralized is many times greater in the major tendons than in the hand so that the countertraction required greatly exceeds that which can be provided by a button on the surface of the skin. Bunnell's technic, therefore, has been modified so that complete skin coverage of the entire fixation apparatus and a solid bony structure rather than a button on the skin for anchorage of the main traction suture are provided.

#### TECHNIC

*Repair of the Tendo Achillis.* 1. A posterior midline incision over the distal one-half of the lower leg, curving laterally at a point 2 cm. proximal to the os calcis to proceed distalward over the lateral surface of this bone to within 2 cm. from the plantar surface of the foot, (Fig. 1c). Lateral curvature of the lower portion of the incision is important for two reasons: (1) The lateral surface of the os calcis requires exposure; (2) posterior midline shoe pressure upon the operative scar is avoided.

2. The ruptured tendon is exposed and the skin incised in the midline from the level of the musculotendinous junction to the os calcis.

3. The degenerated and lacerated end of each tendon fragment is débrided back to healthy tendon tissue. (Fig. 1A, 1.)

4. A small area on the lateral surface of the os calcis is exposed, (Fig. 1A, 2.)

5. A drill is passed through the os calcis from lateral to medial. As it elevates the skin on the medial side of the heel a small stab wound is made. (Fig. 1A, 3.)

6. As the drill is withdrawn a long screw is passed through the hole from medial to lateral. The head end of the screw is left projecting a

short distance through the medial stab wound. (Fig. 1B.)

7. A mattress suture of stainless steel wire is placed in the proximal tendon fragment in such a way that (1) the horizontal portion of the suture is at the level of the musculotendinous junction and (2) a portion of the suture presents upon the superficial surface of the tendon. It is at this point that the removing wire is fastened.

8. The medial end of the suture is passed through the subcutaneous tissues and brought out through the medial incision. (Fig. 1B, 3.)

9. The proximal tendon fragment is pulled distalward by traction on the wire suture until apposition of the fragments has been obtained. The ends of the suture are then fastened to the screw. (Fig. 1B, 2.)

10. Insertion of the screw is then completed. This carries the medial end of the suture into a subcutaneous position along with the screw head. A small nut is screwed down to the lateral surface of the os calcis and the superfluous portion of the screw removed with a wire cutter.

11. Snug and accurate apposition of the fragment ends is completed by a few mattress sutures of fine silk, (Fig. 1B, 1.)

12. A removing wire is fastened to the horizontal portion of the main suture. This is left about 1 inch in length and a split lead shot clamped to the end. (Fig. 1B, 4.)

The wound is closed in layers over the entire fixation apparatus. Both ends of the bolt and the lead shot on the removing wire occupy a relatively subcutaneous position and remain easily palpable. Removal requires a small incision at each of these three palpable points. Local infiltration with procaine hydrochloride provides adequate anesthesia for this purpose. The terminal ends of the main suture are divided and the bolt mechanism unscrewed and removed through the two distal incisions. The lead shot is then identified by palpation and the remainder of the apparatus withdrawn through the proximal incision by traction on the removing wire.

*Repair of the Quadriceps Mechanism.* An operative technic similar to that described for tendo achillis lesions has been utilized for the repair of various tendon ruptures at the knee. In tears of the quadriceps tendon the traction suture is placed at the musculotendinous junction and anchored to a bolt through the patella,

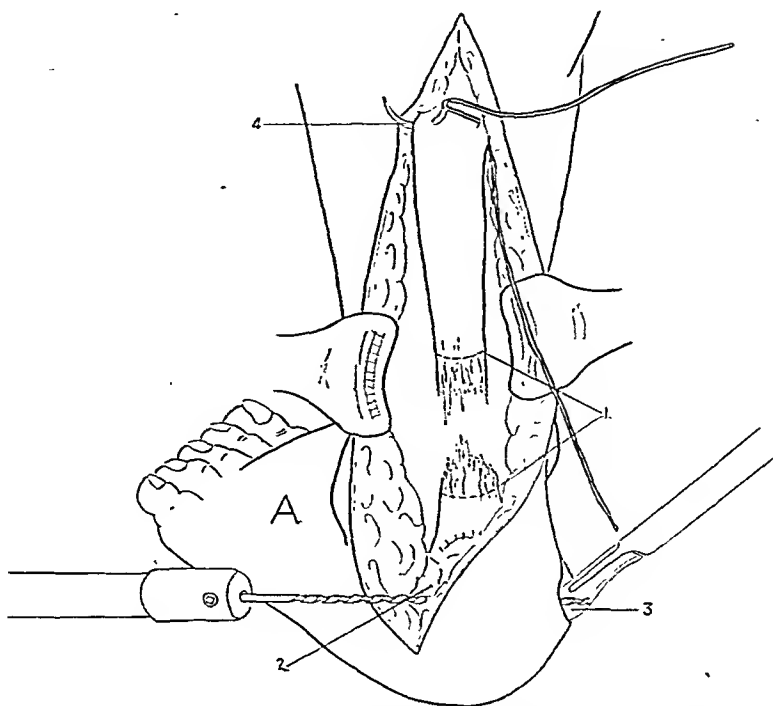


FIG. 1. A, technic for repair of tendo achillis. A, the rupture is exposed and the tendon ends débrided back to healthy tissue (1). A small area on the lateral aspect of the os calcis is exposed and a hole drilled transversely through the bone from lateral to medial (2). A small stab wound is made at the point of emergence of the drill on the medial side of the hole (3). A mattress suture of stainless steel wire is placed through the proximal tendon fragment at the musculotendinous junction (4).

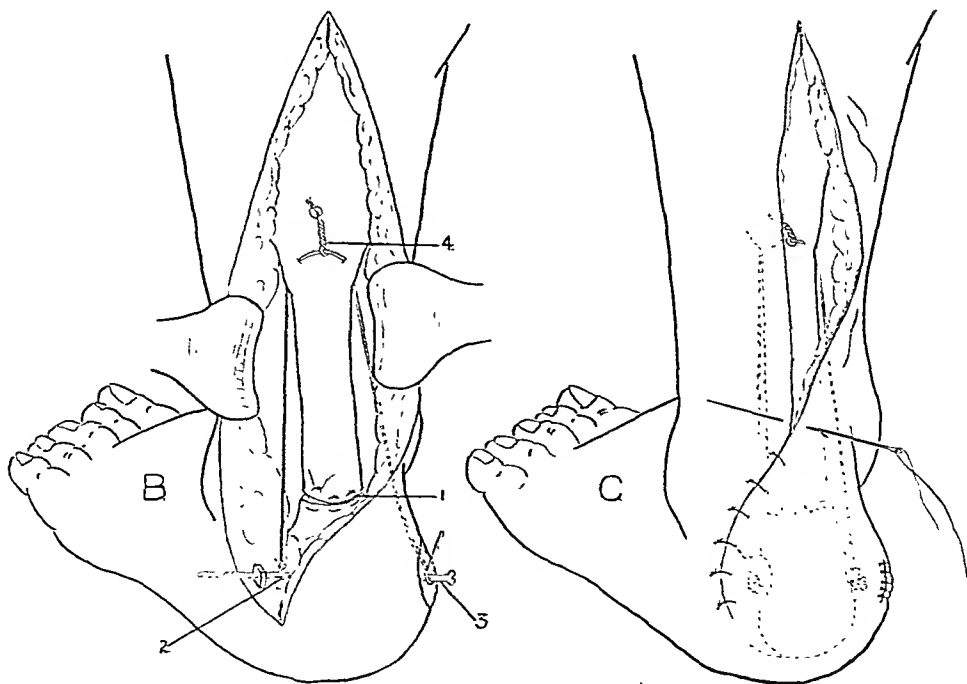


FIG. 1. B, a long screw is passed through the drill hole from medial to lateral (3). The proximal fragment is pulled down into position and the ends of the mattress suture attached to the screw (2). Apposition sutures of fine silk complete the repair (1). A twisted removing wire to which is attached a split lead shot is fastened to the proximal loop of the main suture (4). C, insertion of the screw bolt is completed. A small nut is screwed into the lateral side of the os calcis and the superfluous portion of the screw removed. The wound is then closed over the entire fixation apparatus.



(Fig. 2B.) In patellar tendon tears the suture is placed just proximal to the patella and anchored to a bolt through the tibial tubercle. (Fig. 2A.) A suture placed at the musculotendinous junction and anchored to a bolt through the tibial tubercle has been utilized for temporary

or brace are minimized and ambulation made safe and possible throughout the period required for tendon healing. The results in four patients treated by removable traction suture appear in the accompanying table. (Table 1.)

Tendo achillis repairs are placed on a post-

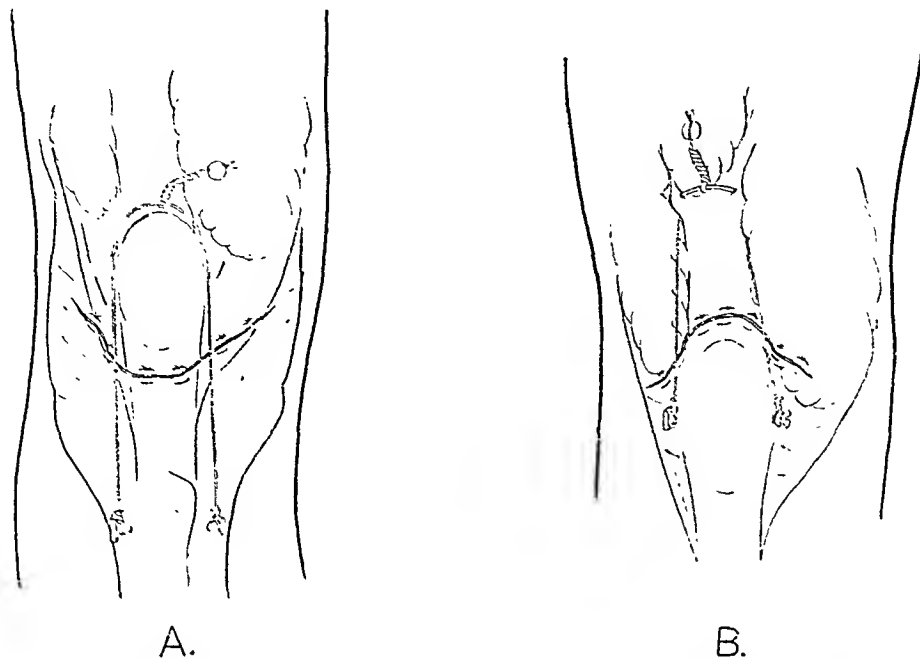


FIG. 2. Technic for repair of ruptures through the quadriceps mechanism. A, repair of rupture distal to patella; B, repair of rupture proximal to the patella.

protection of the reconstructed quadriceps mechanism during the healing period following removal of the patella.

*Postoperative Management.* At all operations for repair of the quadriceps mechanism, just prior to skin closure, the knee joint is passively flexed to determine the arc of motion possible before significant tension occurs at the repair site. Usually this is in the neighborhood of 30 degrees from full extension. Postoperatively the extremity is put at complete rest for forty-eight to seventy-two hours and then placed in balanced suspension. All joints except the knee are mobilized fully. The knee is mobilized throughout the arc predetermined at operation. When the operative wound has healed ambulation with weight-bearing is begun with the involved knee protected by an extension splint or brace. The internal fixation apparatus is removed eight weeks following operation. At the same time all external protection is removed and progressive resumption of normal activities encouraged. As a result of early mobilization followed by subsequent continuous active function the penalties of restricting joint motion by the protective splint

operative program determined by the individual circumstances of each case. One bilateral lesion required no external support but was prohibited from bearing weight until the fixation was removed. Another patient was not allowed to bear weight until the fixation was removed because of a local infection around the bolt. A third patient was allowed to ambulate with crutches and a raised heel as soon as the operative wound was healed. Two patients were allowed to ambulate in a plaster of paris walking boot following wound healing. Two other patients were made to walk on crutches with the repair protected by a removable plaster splint until the tendon was healed due to poor consistency of the tissues at the repair site. The fixation apparatus is removed from tendo achillis repairs six weeks following operation. The knee joint required immobilization in none of the eight complete ruptures treated by a removable suture. The results appear in the accompanying table.

#### CONCLUSIONS.

The results following surgical repair of major tendon ruptures by direct suture, reinforced or

TABLE I

Case No.	Name	Age	Tendon	Duration	Postoperative Program	Ambulation with Weight-bearing (in Days)	Suture Re-moved (in Weeks)	Knee or Ankle Range on Removal	Ordinary Full Activities (in Weeks)	Unre-stricted Full Activi-ties (in Weeks)	Return to Work (in Weeks)	Follow-up—4 = 100 % normal 3 = 75 to 99 % normal					Occupation	Complicating Factors
												Anat.	Range	Sympt.	Econ.	Dura-tion		
1	M. O.	61	Infrapatellar	3 mo.	Knee mobilized then splinted in extension	25	8	50°	4	12	14	4	full	none	4	2½ yr.	Clerk	Incipient paralysis nigrans
2	W. A.	46	Infrapatellar	3 da.	Knee mobilized then splinted in extension	15	.....	..	.....	..	..	Still under treatment			..	.....	Teacher	
3	M. N.	33	Quadriceps	1 da.	Knee mobilized then splinted in extension	22	8	35°	12	16	12	4	30° short	none	4	1 yr.	Housewife	Compound injury to knee joint
4	S. I.	56	Quadriceps	1 da.	Knee mobilized then splinted in extension	23	10	45°	5	16	18	4	full	none	4	6 mo.	Housewife	Pulmonary infarct, postoperative
5	M. T.	56	Quadriceps	6 mo.	Knee mobilized then splinted in extension	18	..	.....	.....	..	..	Still under treatment			..	.....	Housewife	
6	R. H.	26	Patellectomy	1 da.	Never immobi-lized	32	5	45°	8	10	..	3	full	none	4	1 yr.	None	Psychiatric
7	W. R.	42	Tendo achillis	1 da.	Never immobi-lized	13	6	normal	3½	7	8	3	10° defect	none	4	1 yr.	Probation officer	
8	M. S.	58	Tendo achillis	1 da.	Mobilized then crutches and re-movable splint	56	6	5° short of normal	6	10	2	3	5° defect	early fatigue	4	6 mo.	M.D.	
9	I. W.	53	Tendo achillis	5 da.	Mobilized then crutches and re-movable splint	56	6	?	12	12	3	4	full	none	4	1½ yr.	Executive	Wound infection
10	L. R.	26	Tendo achillis	6 wk.	Mobilized then walking boot	10	6	?	10	14	..	Lost	.....	.....	..	.....	None	
11	H. V.	28	Tendo achillis	9 mo.	Mobilized then walking boot	10	6	normal	6	8	2	4	full	none	4	2 yr.	Athletic coach	
12	E. B.	45	Tendo achillis	2 da.	Mobilized then removable splint	42	6	30°	12	16	2	4	full	none	4	1½ yr.	Executive	
13	A. R.	40	Tendo achillis	2 da.	No external sup-port	56	6	30°	16	24	3	4	full	none	4	2 yr.	Executive	Bilateral lesions
14	A. R.	40	Tendo achillis	2 da.	No external sup-port	56	6	30°	16	24	3	4	full	none	4	2 yr.	Executive	Bilateral lesions

not by fascial or other heavy sutures or free grafts, have been characterized by prolonged disability time due to stiff joints, weak muscles and often an incomplete eventual recovery.

A method of internal fixation for such fractured tendons, utilizing the removable traction suture principle evolved by Bunnell, has been carried out in six lesions of the quadriceps mechanism and eight lesions of the tendo achillis.

The results to date have been characterized by a more complete return to normal in less time than was previously possible.

#### REFERENCES

1. BUNNELL, S. *Surgery of the Hand*. Philadelphia, 1944. J. B. Lippincott Co.
2. McLAUGHLIN, H. L. Repair of ruptures through the larger tendons by removable staple suture. *Arch. Surg.*, 52: 547-556, 1946.

#### DISCUSSION

STERLING BUNNELL (San Francisco, Calif.): It is with pleasure that I listened to Dr. McLaughlin's paper developing the use of removable stainless steel wire in the repair of large tendons. This principle in repairing either small or large tendons allows us to avoid using chromic catgut or silk. The knots of the former are a repeated source of trouble. Silk is a foreign body about which a zone of cicatricial tissue undesirable at a tendon juncture always forms.

Stainless steel wire for tendon sutures causes the least tissue reaction to produce adhesions. Tantalum is unfit as it is brittle and rough. After three or four weeks the suture should be withdrawn as by then the tendon has become physiologically united and any suture material is just an irritating foreign body. The suture which gives the least irritative reaction to form adhesions is the suture which is not there.

Tendons pull from one end only, the muscle end, so the suture may be placed in only one of the ends, the two ends lying passively apposed to each other. This suture may even be placed at a distance so no suture material is present at the juncture to interfere with healing or to cause adhesions. The suture is given firm anchorage outside the skin.

I have used this method a great deal in hands and also for large tendons. Certain aspects should be mentioned: One is that when we place a suture in a tendon we must make sure it will withdraw. The hemostat attached to the tendon end is held firmly and the suture and pull-out wire are drawn back and forth until they run freely, just as we test a subcutaneous suture.

A pull-out wire should not have a large loop as tissue may grow through it hindering its with-

drawal. To prevent this the loop should be closed but not too tightly as it may break. If the suture does not withdraw, a rubber band applied usually delivers the wire over night; the tissues yield as does a cake of ice when a wire is held taut against it. To prevent tissue from growing in between two strands of the pull-out wire, these are merely twisted a little.

If the patient is allowed to be ambulatory, it is extremely important to immobilize the anchorage of the wire completely. When a wire passing through the skin is fastened to a button or shot it will, because of motion, break unless held firmly by adhesive. As yet I have not encountered infection from the wire, but this is possible in the presence of motion just as is so frequently found about pins placed in bones. Dr. McLaughlin immobilized by using a screw placed in the calcaneus. I have placed a wire around the calcaneus.

The use of withdrawable stainless steel suture has wide application, having been proved successful in closing abdomens, uniting tendons to bones in hands and feet and in joining ligaments in any region. Complications from silk or chromic catgut are avoided and strong union is maintained until physiologic union takes place. Adhesions are reduced to a minimum. In fixing tendons to feet, one can drill right through the bone, pass the wire through the drillhole and fasten it to a button on the sole. This is a quick way of attaching tendons to bones anywhere in the body, drilling through the bone and passing the wire on through the limb to be anchored externally. When a fascial graft is placed, as at the acromioclavicular joint or around a dislocated radial head, the fascia is not strong at first, so a stainless steel wire following the fascia around the bone may be used to hold the joint in place until the fascia is viable and strong. With a local anesthetic, as Dr. McLaughlin stated, the wire can then be removed.

J. HUBER WAGNER (Pittsburgh, Pa.): Dr. McLaughlin asked me to discuss this paper and I am very glad that Dr. Bunnell was here to open it rather than myself, because I am sure his remarks were more pertinent than mine will be.

Dr. McLaughlin has shown us a very nice adaptation of the principles of the use of stainless steel wire for tendon repair as advocated by Dr. Bunnell. In these particular injuries, in my experience, I have found these so-called spontaneous ruptures to come in the middle or old-age group. In youth and young adults the cases that we see due to steel cuts, both of the quadriceps and the tendo achillis, the repair is easier and healing early; but in the aged and middle-age group, this method permits, as has been shown by Dr. McLaughlin, the use of the part or the muscles within the physiologic limit, so that the atrophy that rapidly takes place in these individuals is not necessarily eliminated but is certainly cut down to a marked degree.

Very often, one sees the after-results in these ruptured tendons that have been repaired by the use of black silk and other material, with suture only at the site of fracture, with prolonged immobilization and then later a deformity and painful tumor at the site of the repair. This latter needs exploration with plastic resection. The tumor is usually of a xanthomatous nature. With removal of the foreign body and tumorous tissue, the function is improved and the pain materially cut down.

In the use of the transfixation pin or bolt, I would suggest rather the use of a properly measured stainless steel screw with enough projection on either side of the patella or the os calcis. This would give enough anchorage for the wire when applied and would then permit easier removal at a later date. I offer this as a suggestion to Dr. McLaughlin.

HARRISON L. McLAUGHLIN (closing): I would like to re-emphasize the point Dr. Bunnell brought out about twisting the removing wire. We have made this a routine procedure ever since it was found necessary to re-operate on one patient in order to disengage an untwisted removing wire which had become embedded in newly formed tissue. It takes but a few seconds to twist the wire

and eliminate such a possibility. A bolt or screw is used as the anchorage point for the traction suture because this form of fixation has been found easiest to remove. If the suture is placed through a drill hole in the bone, most of its tension is exerted at either extremity of the hole. It has been believed that under such circumstances the wire might cut through the bone because of the strength of the opposing muscle forces when dealing with the lesions of the larger tendons.

In the early cases an attempt was made to make the bolt exact in length. However, it was so easy to remove the superfluous portion that it has now become a routine practice to use a longer screw than necessary and cut it down to exact length with a large pair of wire cutters after it is in place.

I expected to be asked whether or not the wire suture has shown any tendency to cut through the tendon proximal to the repair site. It has not done this in any case. This is probably due to the fact that the suture is placed through healthy tendon tissue as far proximal to the rupture as is possible, and to the fact that it is exposed to intermittent rather than constant tension.



# INTRAVENOUS PROCAINE IN THE TREATMENT OF TRAUMA\*

## PRELIMINARY STUDY

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PAIN and post-traumatic edema are perplexing problems for the surgeon. The osteoporosis associated with edema which appears at a later date is more troublesome. During the past year in an attempt to solve these problems we have given 303 intravenous procaine† infusions to 140 patients suffering from trauma. Some of our results seem to indicate that procaine administered intravenously does lessen the edema and pain. For a time we were of the impression that the healing process was accelerated; however, the number of cases is too few to warrant any definite conclusion.

Following trauma the response of the tissues is a defense mechanism. The vasospasm and the exudate which are found at the site of trauma subside in the majority of instances at the conclusion of the healing process. If, however, the vasospasm and the edema persist, an irritative focus is said to exist. In most of our patients we believe that we were able to alter the reflex arc which produces these manifestations so that pain, spasm and edema were reduced. We believe, too, that the healing process was accelerated.

### PATHOLOGIC PHYSIOLOGY

It is the consensus of opinion that histamine<sup>2</sup> or a histamine-like substance<sup>3</sup> is liberated at the site of trauma and that a three-fold complex result follows: (1) hyperemia; (2) increased permeability of the vessels and (3) increase of the local lymph and venous circulation.<sup>4</sup> Histamine is said to act as a persistent stimulus to the sensory endings of the terminal axon branchings. The chemical and structural similarity between acetylcholine, choline and procaine, which is a local anesthetic, has been shown.<sup>1</sup> Since it is agreed that vasodilatation

will relieve the pain syndrome, it must be concluded that histamine is not an effective producer of acetylcholine at the terminal junction of the axon branchings because of (1) the failure of hyperalgesia to appear about the site of trauma following local injury while a local anesthetic holds and (2) experimental evidence of vascular contractions prevailing over local vasodilatation due to histamine.<sup>5,6</sup> It should be noted that there is some experimental evidence as to the existence of a spinal outflow of parasympathetic fibers which can produce a cholinergic response by reflex stimulation of a depressor nerve.<sup>7,8</sup>

Whether one calls the reaction a local disorder or reflex<sup>9</sup> the nervous responses are the same. The irritation of the nerves of the skin, muscles and blood vessels produce a vasospasm.<sup>10-12</sup> Vasospasm plays an important rôle in the mechanism of pain.<sup>13,14</sup> This reflex may spread centrally to involve entire limbs.<sup>9,15,16</sup> It has been reported that renal anoxia was found following trauma of an extremity as a result of stimulation of the sympathetic nerves of the extremity rather than the peripheral circulation.<sup>17</sup>

Edema following injury is due to (1) capillary permeability and decompensation and (2) increased collateral circulation. Histamine increases the permeability of capillaries.<sup>18,19</sup> The dysfunction or decompensation is due in part to venous congestion.<sup>20-22</sup> In the pathologic state the capillary membrane may become as permeable to colloids as it formerly was only to ions.<sup>23-26</sup> It is postulated that the increased blood flow in the injured extremity results from resistance by edema to the passage of oxygen into the tissues; that the effect of this in addition to (and in spite of) increased blood flow is tissue anoxia.<sup>27</sup> Leriche has demonstrated the extensiveness of the collateral circulation<sup>28</sup> and others have shown the establishment of arterio-venular anastomosis.<sup>29,30</sup>

Direct treatment to the affected neuron is

† Procaine used in this study was "Novocain," generously supplied by the Department of Medical Research, Winthrop Chemical Co., N. Y., N. Y.

\* From the Traumatic Surgical Service of the Reconstruction Hospital Unit, New York Post-Graduate Medical School and Hospital.

the treatment of choice.<sup>31</sup> Local infiltration of procaine at the site of trauma,<sup>32,33</sup> although satisfactory, presents many disadvantages in that complete anesthesia is not always accomplished; "after pains" are usually present and frequent repetition is required. Knowing that at the site of trauma capillary permeability would allow procaine to enter the tissues it was believed that the vascular approach would produce better and more rapid results.

One is familiar with the boggy, cold and painful ankle following a Pott's fracture, wherein the disability of twelve to fourteen weeks or longer is anticipated, due not so much to the failure of bony union as to soft tissue changes with mild or severe vasospasm and osteoporosis of various degrees.<sup>34</sup> To summarize, we believe a prolonged stimulation of pain impulses reaching the injured, irritable, non-insulated sensory neuron through an antidromic reflex are may perpetuate itself in a vicious circle of reflexes. The constant circling within the internuncial pool will include the sympathetic motor neuron cells in the lateral horn. Vasospasm at the arteriolar and venular portions of the capillary increases the filtration pressure with the formation of edema and swelling. Anoxia and cyanosis increase capillary permeability and edema. There are three sensory levels: the primary or peripheral, the secondary or spinal and the tertiary or cerebral. Although treatment of the primary neuron is advocated, many have attacked the secondary neuron or sympathetic pathway.<sup>35</sup> Procaine injection administered intravenously blocks the primary neuron at the source of irritation. It has been proven that procaine given intravenously will be concentrated seven to eight times more in traumatized tissue than in normal tissues.<sup>36</sup>

**Dosage.** The dosage we have employed is the "procaine unit";<sup>1,37</sup> 4 mg. of procaine hydrochloride per kilo body weight dissolved in an isotonic saline solution to make a 0.1 per cent (1:1,000) solution to be administered in a twenty minute period. Using the flowroter,<sup>38</sup> an instrument which measures the number of cc. of solution entering the patient's vein per minute, the administration is simplified and controlled. The error factor by this method is less than  $\frac{1}{2}$  of 1 per cent.

#### CLINICAL DATA

All our cases were treated as outpatients or inpatients. No premedication such as barbitu-

rates was given. No sensitivity to procaine has been found in over 2,000 infusions given for various conditions. In this series of traumas the youngest patient treated was seven years of age and the oldest was seventy-nine.

TABLE I

Classification	No. of Cases	No. of Infusions
Fractures.....	55	91
Postreduction arthralgia.....	8	33
Sprains.....	14	14
Intervertebral disc.....	7	14
Myofascitis.....	18	46
Traumatic arthritis.....	7	24
Causalgias.....	30	80
Miscellaneous lacerations.....	1	1
Total.....	140	303

Table I represents the number of cases treated in this series with the number of injections given in each subdivision. The fractures treated were seen within twenty-four to forty-eight hours after trauma, the variation in time representing the period between the time of trauma and the admission to the hospital.

**Fractures.** The fifty-five cases represented fractures of various types, excluding compound fractures, and involved most parts of the body. Thirty patients were given procaine infusions prior to reduction with considerable relief of pain but in only two cases was reduction possible under this anesthesia. It should be noted that procaine given intravenously is not satisfactory as an anesthetic. The other twenty-five patients were treated postreduction and all had immediate relief of pain to a greater or lesser degree. The repetition of infusions was necessary because, although the pain which returned was very mild, complete relief was desired. Postreduction sedatives were not necessary.

#### CASE REPORTS

The following cases are typical in our series:

**CASE I.** No. 36259. E. M., a sixty-one-year old female, a schoolteacher, fell and injured her left wrist sustaining a Colles' fracture as well as a fracture of the styloid of the ulna with displacement. Reduction was accomplished under general anesthesia and plaster of paris splints were applied.

The first day after the accident the patient complained of throbbing, burning pain in the left

wrist and hand. Examination revealed marked swelling of the fingers and dorsum of the hand and inability to move her fingers. The weight of the patient was 50 Kg. and she was given 200 cc. of 0.1 per cent procaine hydrochloride solution. Immediately following the infusion there was marked lessening of pain and she was able to move her fingers more freely. The patient stated on the third day that she had no pain. The edema had subsided requiring readjustment of splints. Ten days after the accident a radiologic examination revealed early callus formation. Splints were discarded and early motion was encouraged. Fourteen days after admission the patient reported that she was doing housework without pain except when extreme flexion or extension of the wrist was required. A procaine infusion was given and active and passive extension and flexion of the wrist was accomplished without pain. Six weeks after the accident occurred the patient was discharged with no evidence of disability.

CASE II. No. 37715. M. F., a forty-three year old female clerk, tripped and fell injuring her left ankle twenty-four hours prior to admission. Examination revealed a markedly swollen and edematous ankle and foot. Radiologic examination revealed a non-displaced transverse fracture through the distal end of the fibula. Her weight was 65 Kg. and 260 mg. of procaine hydrochloride were administered intravenously. There was immediate relief of pain and active motion in the ankle caused no pain. Plaster of paris splints were applied.

Three days later procaine infusion was repeated because of slight pain and a plaster casing was applied. After twelve days the casing was removed and radiologic examination revealed partial obliteration of the fracture line. The patient was able to wear a shoe and able to walk. There was no pain twenty-one days after admission. Only slight dependent edema could be noted. Radiographic examination revealed healing of the fracture. Six weeks after the accident the patient was discharged.

*Postreduction Arthralgia.* There were six patients with dislocation of the shoulder and two with dislocation of the elbow. They were all reduced under general anesthesia and had severe postreduction pain and limitation of motion. The elbow cases, in addition, had severe swelling due to hemorrhage. Procaine administered intravenously produced immediate relief of pain in all instances. Repetition was deemed necessary in order to diminish muscular spasm.

CASE III. No. 36448. R. M., a twenty-five year old male delivery boy, fell injuring his right shoulder. Reduction was accomplished under gen-

eral anesthesia and the arm was fixed to the chest wall and the forearm suspended.

One day later his weight was determined as 64 Kg. and 256 mg. of procaine were given for the severe shoulder pain. He obtained immediate relief. The next day procaine infusion was given, the bandage removed and active motion started. Slight restriction of motion was noted. Four days after the accident active motion was equal to the opposite extremity except for slight muscular spasm. Procaine infusion was given. The patient returned to work on the seventh day following the accident symptom-free and on the twenty-first day after the injury he was discharged with no evidence of disability.

CASE IV. No. 36438. A. K., a thirty-nine year old male accountant, slipped on the ice and sustained posterior dislocation of the left elbow. Reduction was accomplished under general anesthesia. Edema and hemorrhage were so severe that upon flexion of the elbow obliteration of the radial pulse was noted. His weight was 68 Kg. and 272 mg. of procaine were administered. The throbbing pain was relieved and passive flexion could be accomplished without obliteration of the radial artery.

The second week after the injury there was marked reduction in the swelling and edema about the elbow. There was a 10 per cent limitation in flexion and extension. Procaine infusion was given. The patient returned to work three weeks after the accident and extension was restricted 10 degrees; flexion was normal. The patient was discharged symptom-free six weeks after the injury occurred. The total number of infusions was eight.

*Sprains.* All these cases involved the ankle and radiographically revealed no evidence of fracture. The reduction of pain and the increase in mobility were noted immediately after an infusion of procaine. Repetition was not required and patients were symptom-free during the period of observation.

*Intervertebral Disc Rupture.* All of the cases in this series were found to have rupture of the intervertebral disc at operation. Procaine administered intravenously does not relieve the pain or spasm in this condition. These cases are typical of the pain syndrome due to direct pressure. It has been reported<sup>1</sup> that this method is being used as a differential diagnostic aid in determining low back pain.

*Myofascitis.* The low back pain syndrome due to an inflammatory condition responds very satisfactorily following the intravenous administration of procaine. The reduction of pain and the diminution of spasm were noted immediately. The relief of pain is immediate



and usually lasts several days at which time the pain that does return is considerably less. The average patient requires approximately three infusions in a two week period. Observation of these few patients for two months following the beginning of the treatment revealed no recurrences.

**Traumatic Arthritis.** In a recent report<sup>32,40</sup> we discussed the dramatic relief of pain and increased mobility in traumatic arthritis. The following case is typical in the series:

**CASE V.** No. 35058. H. R., a thirty year old single male clerk, sustained a fracture through the left elbow joint two years prior to admission. He suffered a great deal of pain and limitation of motion. His weight was 50 Kg. and he received 200 mg. of procaine. The relief of the pain and spasm was immediate. For the past six months there has been no recurrence of pain or disability in the left elbow joint.

**Causalgias.** The symptom complex of reflex sympathetic dystrophy has always been a challenge to the surgeon. The effect of procaine administered intravenously in these patients is dramatic. The action of procaine given intravenously is at the primary or peripheral neuron.

**CASE VI.** No. 20319. E. F., a thirty-nine year old single female clerk, sustained a sprain-fracture of the cuboid of the right ankle one year prior to admission. She had pain, swelling, hyperhidrosis and marked sensitivity to thermal changes. Examination revealed a mild cyanotic swelling over the dorsum of the foot with marked sensitivity to pressure and examination. Radiographic examination showed osteoporosis of the metatarsal bones. Her weight was 60 Kg. and 240 mg. of procaine were given intravenously. There was immediate relief of pain and tenderness and there was a return to normal of the color of the skin. It is now six months since her first and only infusion and there has been no return of symptoms. Radiographic examination three months ago revealed no evidence of osteoporosis.

**Miscellaneous.** There was one patient with a laceration of the dorsum of the hand which, in our early investigation, we attempted to repair under intravenous procaine analgesia. The operative repair was performed without difficulty and without pain. This patient is mentioned as a suggestion in the management of severe lacerations in which general anesthesia is contraindicated or regional anesthesia not feasible.

## COMMENTS

Most peripheral pain is bound to cause a reflex vasoconstriction in the same and also in other vascular areas. That vasospasm interferes with the normal healing process is well established. In the limited number of our fracture cases in which intravenous procaine was used, the early manifestations of increased mobility, relief of pain, evidence of early callus formation in some instances, as well as the obliteration of fracture lines, prompted us to investigate the healing process of fractures in experimental animals. Our first preliminary study in forty rabbits whose femurs were fractured and the animals sacrificed at stated intervals has revealed no difference in the formation of osteoid tissue, calcification or callus formation. Twenty of these rabbits were treated as controls. Histologically there was no change in the soft structures at the site of trauma. Radiographic comparisons were not conclusive. Despite the discouraging experimental results further investigation along the above mentioned lines is the subject of our present study.

## SUMMARY

There is evidence, as a result of our investigations, that interference with the reflex arc established following trauma will hasten the recovery and rehabilitation of the injured individual.

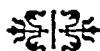
## CONCLUSIONS

1. Intravenous procaine is a safe hospital procedure provided the administration is controlled.
2. Relief of pain and spasm has produced beneficial results.
3. The action of intravenously administered procaine in the healing of fractures is the subject of present study.
4. Early rehabilitation is helped by this method.

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# KIRSCHNER WIRE TRACTION IN ELBOW AND UPPER ARM INJURIES\*

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**F**REQUENTLY certain injuries in the region of the elbow require something more be done than simple closed reduction of the fracture followed by immobilization for a set period of time. Not only is it necessary to alter the usual form of conservative treatment in order to obtain a better reduction and to retain as much function as possible in the joint, but it is imperative that serious complications such as Volkmann's ischemic paralysis, myositis ossificans and permanent nerve injuries be avoided. The routine use of the Jones position of acute flexion of the elbow is not only too frequently used after reduction is obtained, but one might surmise from reading some of the older text books that this position was advocated for the purpose of reducing the fracture. Under no circumstances should acute flexion be used to reduce a badly displaced supracondylar fracture of the humerus and even after reduction this position should not be used if it interferes in any way with the radial pulse. If this rule were followed, an ischemic paralysis would very rarely result. Myositis ossificans could largely be avoided if repeated unsuccessful attempts at closed reduction were not carried out and if passive motion, forceful stretching exercises, etc., were not given subsequently in the false belief that they assist in rapid recovery of function. Permanent nerve injuries could likewise be lessened by early reduction which does away with compression of the nerve or by the omission of repeated attempts at reduction which may cause additional trauma during each procedure.

An attempt has been made during the sixteen years between 1930 and 1945 at the Presbyterian Hospital, New York City, to study a particularly useful method of treatment in a large number of cases and the results of this study are highly gratifying from the standpoint of immediate care of the patient and also from the late follow-up results.

The method of Kirschner wire skeletal traction, though not originated at this institution,

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has been considered by the members of the staff of the Fracture Service to answer many of the difficult problems in the treatment of elbow and upper arm injuries that could not otherwise be readily or safely solved. This method of skeletal traction as applied through the olecranon process of the ulna has been used extensively in two groups of cases. The first group consisted entirely of the more serious type of supracondylar (or transcondylar) fracture of the lower humerus in children. The second group of cases included a rather wide variety of injuries in the lower extremity of the humerus, the humeral shaft and upper extremity of this bone, largely, but not entirely in adults. In the first group of supracondylar fractures in children the method has been most satisfactory and has frequently been the only safe method available. It might be well to explain that much the same form of treatment and possibly equally good end results may be obtained by means of the Dunlap method of skin traction. The reason we have not tried this latter method extensively is because we got started on the Kirschner wire form of traction several years prior to the use of Dunlap traction and found it so satisfactory and in some ways preferable to the other method that we have continued its use.

The second main group of cases treated with Kirschner wire traction has been very satisfactory in particular types of injuries, but much less so in others. An analysis of the cases has convinced us that the method, even if not completely satisfactory as a means of maintenance of reduction, may have considerable advantage as an ante-operative or postoperative adjunct to surgery. These cases will be discussed further on in this paper.

## THE USE OF KIRSCHNER TRACTION IN SUPRA-CONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN

Approximately 60 per cent of all children's supracondylar fractures are of a mild variety with little or no displacement of the distal

fragment. These require either no reduction or merely flexion and splinting in this position. In these the loss of position of the distal fragment is mainly angulation rather than actual shift of the fragment. The remaining 40 per cent of supracondylar fractures in children are serious from the standpoint of displacement and soft tissue swelling. The surrounding soft part damage is directly proportional to the type and amount of displacement of the fragments. All of these require reduction and the sooner that this is accomplished and the more completely it is accomplished, the better are the chances for overcoming any circulatory embarrassment. Of these supracondylar fractures requiring reduction about 75 per cent can be reduced adequately by traction and manipulation under general anesthesia, and the reduction can be maintained by immobilization of the elbow in a posterior molded splint in flexion to a degree which will not compromise the radial pulse. However, about one-fourth of these serious supracondylar fractures (comprising approximately 10 per cent of all supracondylar fractures) are extremely serious cases even when treated by skilled surgeons and in well equipped hospitals or clinics. The reasons for this are: (1) Immediate circulatory damage and the possible threat of Volkmann's ischemia; (2) difficulty in reducing and maintaining reduction of the fracture; (3) frequency of other associated lesions to bone or the surrounding soft parts; (4) late deformity with reversed carrying angle at the elbow and (5) myositis ossificans.

How many times has one met with such difficulties? The answer is "all too frequent" if one has treated more than a few dozen such fractures in children. It is very disconcerting to find difficulty or inability to reduce such a fracture adequately or to be able to reduce it, and to discover that an attempt at flexion results in diminution or obliteration of the radial pulse. Even if reduction and flexion for maintaining the reduction be accomplished, it not infrequently follows that some hours later the pulse becomes feeble or absent owing to delayed swelling around the elbow or to constrictive bandages holding the splint in place. Such a condition, if allowed to persist, will almost certainly lead to Volkmann's ischemia—a major catastrophe. To remove the bandages and splint and to decrease the amount of flexion in order to bring back the pulse will almost certainly allow re-displacement of the fracture

fragments. It should be emphasized that Volkmann's ischemia is not always the result of flexion, splinting or tight bandaging. It may occur without any treatment having been instituted. There are also times when the surgeon is "up against it," because there are other fractures in the same extremity; or because the supracondylar fracture was originally compounded (contaminated) and acute flexion of the elbow makes it difficult or impossible to inspect or dress the wound without fear of losing the reduction.

In the more serious cases we have resorted to the use of Kirschner wire traction and overhead suspension and have formulated four criteria necessitating the use of this method. These are: (1) Where it is impossible to reduce the fracture by any other closed form of manipulation; (2) where it is possible to reduce the fracture, but impossible to maintain the reduction by plaster splint or other means; (3) where there is circulatory impairment either before or after reduction (excessive swelling, weak or absent pulse and a question of impending Volkmann's ischemia); (4) where there are other associated lesions in the same extremity, such as additional fractures, nerve injuries or where the original supracondylar fracture is compounded.

#### METHOD OF INSERTION OF KIRSCHNER WIRE

The insertion of the Kirschner wire should be carried out under strict aseptic technic. In children it is best to do this under general anesthesia, because of pain in handling the arm during the insertion and the setting up of the traction and suspension apparatus. The entire elbow region should be shaved, cleaned with soap and water and painted with iodine and alcohol. An assistant maintains gentle traction on the forearm, and sterile towels are draped over his hands. A small incision is then made approximately 1 inch or slightly more below the tip of the olecranon process of the bone on the ulnar side to avoid damaging the epiphyseal plate. A large bore, No. 15 gauge needle is then inserted in this incision until its point reaches the posterior crest of the ulna; while holding the point of the needle on the bone the operator then moves the entire needle volarly in order to displace the muscles and the ulnar nerve away from the point of the insertion of the Kirschner wire into the ulna. A sterile assistant must then hold this needle point against the

bone and keep the needle in a plane parallel to the posterior aspect of the forearm. The operator uses the needle as a cannula, inserting the Kirschner wire through it, and then drills the latter through the bone. When the point of the needle bulges beneath the skin on the lateral

traction, following which the improved position can be maintained by the traction. As swelling and induration rapidly subside it is frequently possible to have the patient begin mild active exercises for the elbow while still in traction and with complete safety. As soon as x-ray

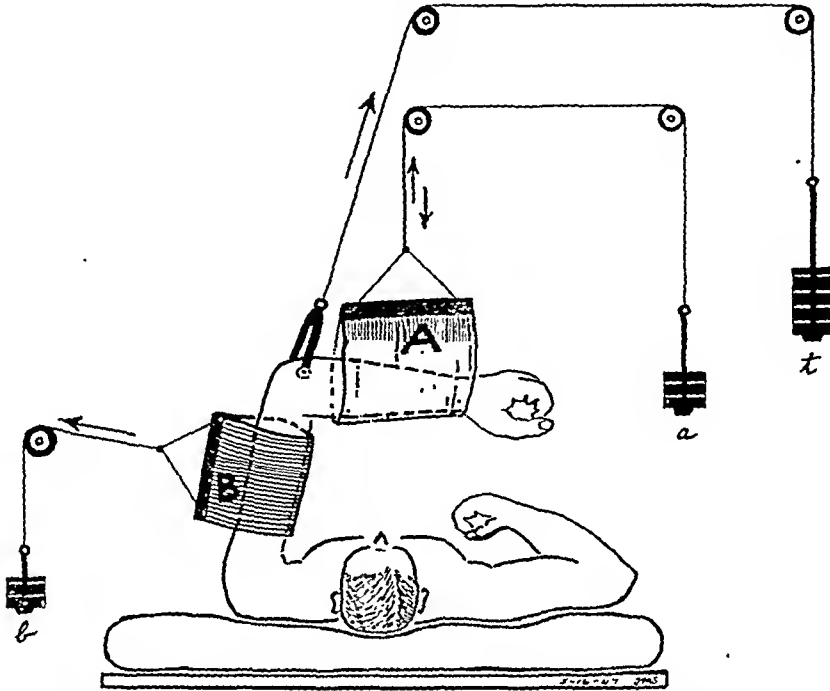


FIG. 1. Sketch demonstrating use of overhead traction and suspension by means of a Kirschner wire inserted through the olecranon. Weight (*t*) provides traction upon the lower humeral fragment via olecranon in a distal and forward direction. The amount of weight necessary is usually between 4 to 6 pounds, depending upon the size of the child. Body weight acts as countertraction. Swathe (*A*) supports the forearm. Weight (*a*) counterbalances the forearm and assists in exercising the elbow joint while still in traction. This weight usually amounts to 2 to 3 pounds. Swathe (*B*) is not always necessary but may be applied if additional pull on the proximal humeral shaft is desired in a posterior direction. Weight (*b*) should be 2 to 3 pounds. If rotation of the fragments needs correction, this may be accomplished by changing the horizontal axis of the forearm by shifting the pulley about Swathe (*A*) toward the head or foot of the bed.

side, a small nick is made over this and the wire brought out on this side. The needle is then removed, the skin wounds are covered with small sterile dressings and a yoke and tightener are then applied to the Kirschner wire. The yoke is then rigged up for traction and suspension as shown in Figure 1.

It is sometimes advisable after twenty-four or forty-eight hours of this traction, if the reduction is not completely satisfactory and there remains either some posterior displacement of the lower humeral fragment or rotary deformity, to give the patient a general anesthetic and again manipulate the fracture while it is still in

films show good evidence of callus formation along the posterior aspect of the humerus, the distal fragment will no longer slip out of position and the Kirschner wire may be removed. The elbow should then be immobilized in a posterior molded splint in moderate flexion as though it were any other fracture reduced and thus splinted. The swelling will have diminished to such an extent by this time that one no longer need worry about development of Volkmann's ischemia from mild flexion. The average duration of time that these patients have been kept in Kirschner wire traction has been approximately thirteen days.

## ADVANTAGES OF KIRSCHNER WIRE OVERHEAD TRACTION AND THE REASONS FOR ITS SUCCESS

1. The patient is hospitalized and under constant observation.
2. He is in bed and is unable to fall and re-injure himself.

## ANALYSIS OF CLINICAL CASES TREATED BY KIRSCHNER WIRE TRACTION

*Group A. Supracondylar Fractures of the Humerus in Children.* From 1930 to 1945 inclusive there have been 402 fresh cases of supracondylar fracture of the humerus in children

TABLE I

## SUPRACONDYLAR FRACTURE IN CHILDREN

A. Inability to reduce fracture by other closed methods.	2, 3, 4, 10, 14, 18, 26, 32, 36, 38, 39
B. Inability to maintain reduction by flexion and plaster fixation.	1, 9, 11, 13, 16, 19, 21, 22, 25, 29, 30, 34, 35
C. Severe circulatory impairment prior to or after closed reduction.	6, 7, 8, (9), 15, (19), 20, (22), (24), (25), (26), 28, (30), 37 5 (compound)
D. Associated lesions (compounding of fracture, other fractures, or nerve lesions).	(10) (fracture shaft of radius and ulna) 12 (compound fracture of wrist) 17 (compound; post. interosseus nerve palsy) 23 (compound) 24 (fracture at wrist; post. interosseus nerve palsy) 27 (compound) 31 (compound; radial and ulnar nerve palsies) 33 (compound) (37) (median nerve palsy)

The case numbers are grouped according to the principal reason why Kirschner wire traction was used in each. Numbers in parentheses are grouped according to additional reasons for use of the treatment.

3. Skeletal traction is employed which is much more efficient than skin traction in obtaining as well as maintaining reduction of the fracture.

4. The injured part is held in high elevation which permits venous and lymphatic drainage to be assisted by gravity, thus permitting rapid decrease in swelling.

5. The Jones position of acute flexion is unnecessary to maintain reduction and thereby circulatory impairment is lessened.

6. There is no necessity for any constricting dressings to maintain position of a splint.

7. The method is painless and thus of extreme importance in children.

8. It allows early active elbow motion without the danger of complete loss of position of the fragments.

9. The anterior aspect of the elbow region is accessible at all times for dressings of a compound wound.

10. The method does not interfere with reduction or immobilization of associated wrist or forearm fractures.

11. It also permits the use of a cock-up splint for the wrist and hand in the event of an associated radial nerve injury.

treated on the Fracture Service of the Presbyterian Hospital, New York City. Old cases with complications or malunions have not been included in this number. Of the 402 fresh injuries of this type thirty-nine cases (or 9.7 per cent) have been considered serious enough to warrant treatment by over-head skeletal traction. It has not been our practice to operate upon supracondylar fractures for the purpose of obtaining open reduction of the fragments or for the relief of impaired circulation except in extremely rare instances. The results of this study clearly demonstrate that open operation is unjustified in this type of fracture in general. With the exception of six cases of compound fracture in which operative débridement was a necessity, only three patients (0.75 per cent) of the entire 402 cases had open operation performed upon them.

One frequently hears discussed the necessity for open reduction where wide displacement of the fracture fragments is seen on x-ray films, where swelling is excessive and the pulse feeble or absent and where associated nerve lesions are present. In the first place operation carries some risk of infection, does not guarantee maintenance of accurate reduction of the fragments,

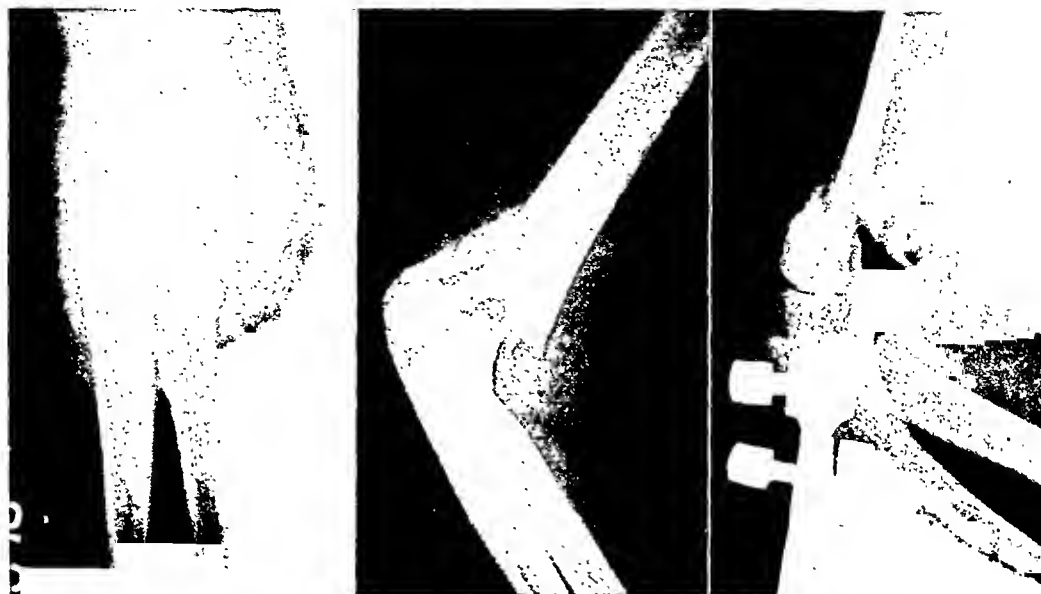


FIG. 2. J. G., female, age seven and one-half years, supracondylar fracture of humerus treated by Kirschner wire traction and suspension. A and B, anteroposterior and lateral films showing original displacement. C, lateral view after two days in overhead traction showing some residual posterior displacement.

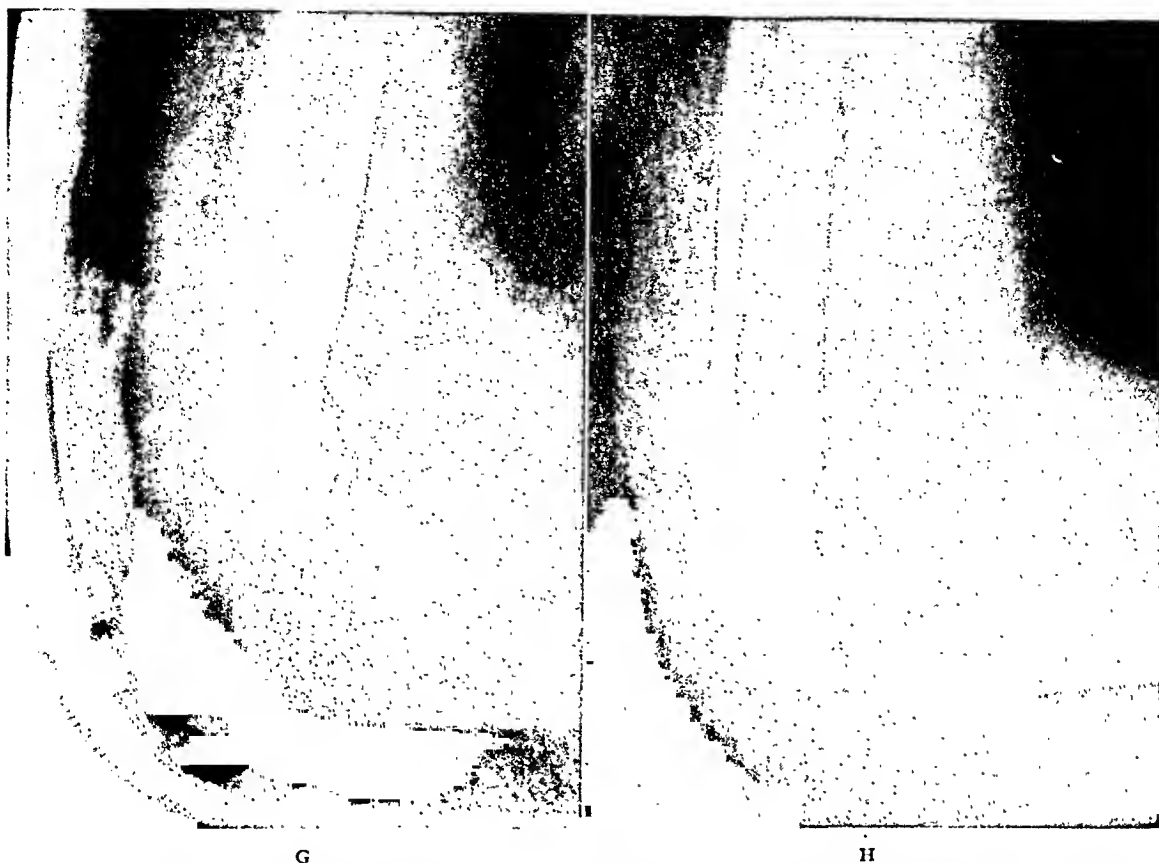


FIG. 2. D, anteroposterior view and E, lateral view after four days in traction. The posterior displacement of distal fragment has been largely overcome but some rotation persists. F, lateral view on sixth day of traction and two days following manual correction of rotation deformity under anesthesia.

and, if performed at a period of one to two weeks after injury, it may lead to extensive formation of myositis ossificans. In the second place it is rarely ever necessary to split or decompress the deep fascia overlying the anterior elbow region to overcome circulatory embarrassment if over-head traction is carried out as described. And third, original nerve injuries are usually the result of contusion or pressure from a bone fragment or the result of overstretching.

There is little fear of actual severance of one of the nerves in this region except by gunshot or a sharp cutting object. Operation in the presence of severe hemorrhage, muscular damage, etc., may likewise be extremely risky because of distortion of the anatomy and masking of important nerve trunks. It is our belief that Kirschner wire over-head traction is not only safer by virtue of being more conservative but performs all that open operation can do and just as well.

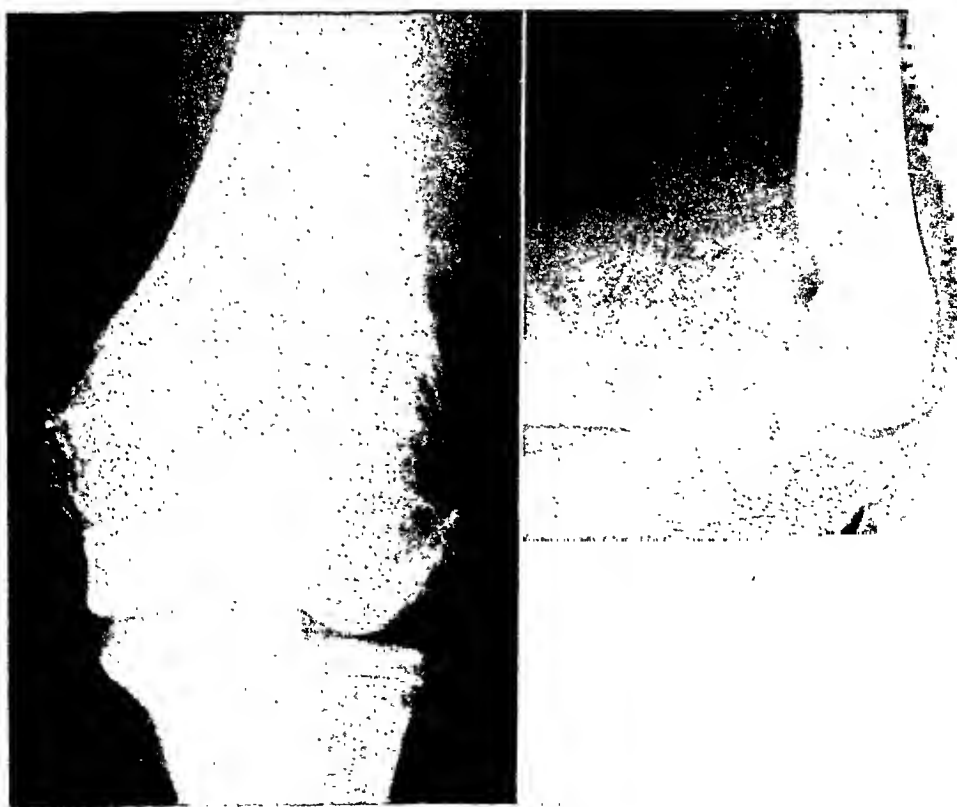




G

H

FIG. 2. G, lateral view on sixteenth day after injury, following removal of Kirschner wire and application of posterior molded splint. (Note good position and abundant early callus.) H, lateral view at seven weeks.



I

J

FIG. 2. I, anteroposterior and J, lateral views four years four months after original injury. (Result: full function, use and no deformity.)



FIG. 3. M. McM., female, age nine years; supracondylar fracture of humerus with associated partial paralysis of median nerve treated by Kirschner wire traction and suspension. A and B, anteroposterior and lateral films showing original marked displacement. C, anteroposterior view after one day of traction.

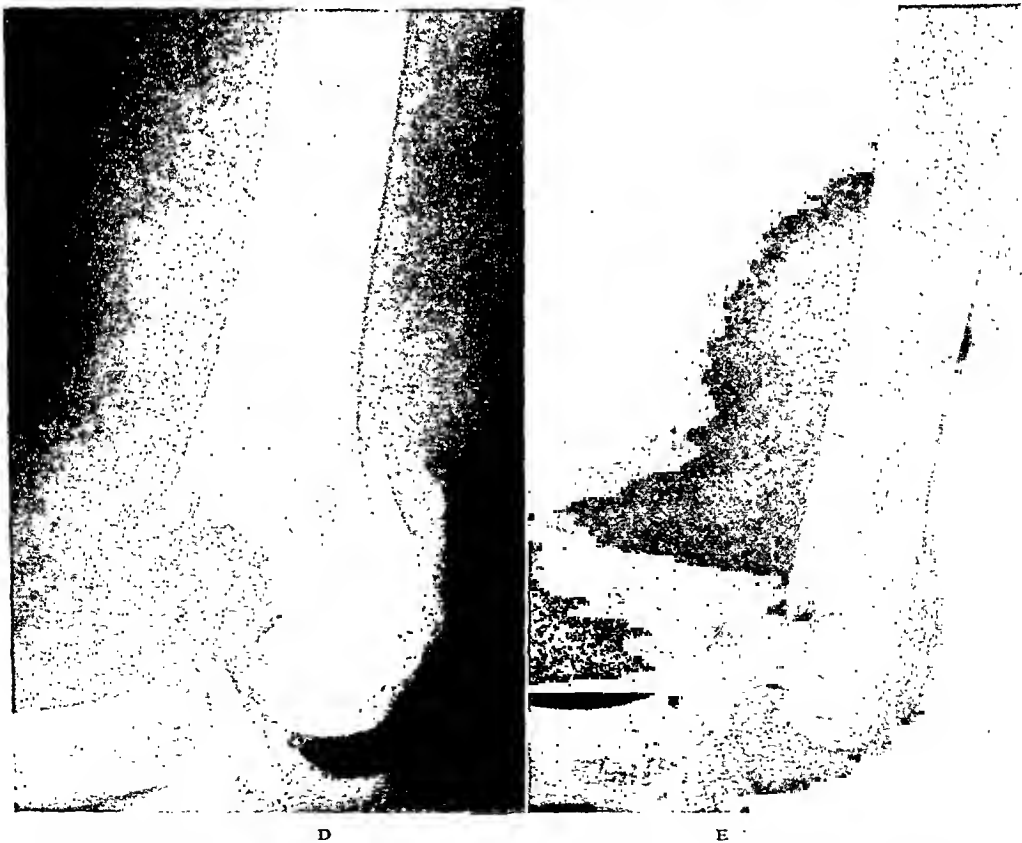
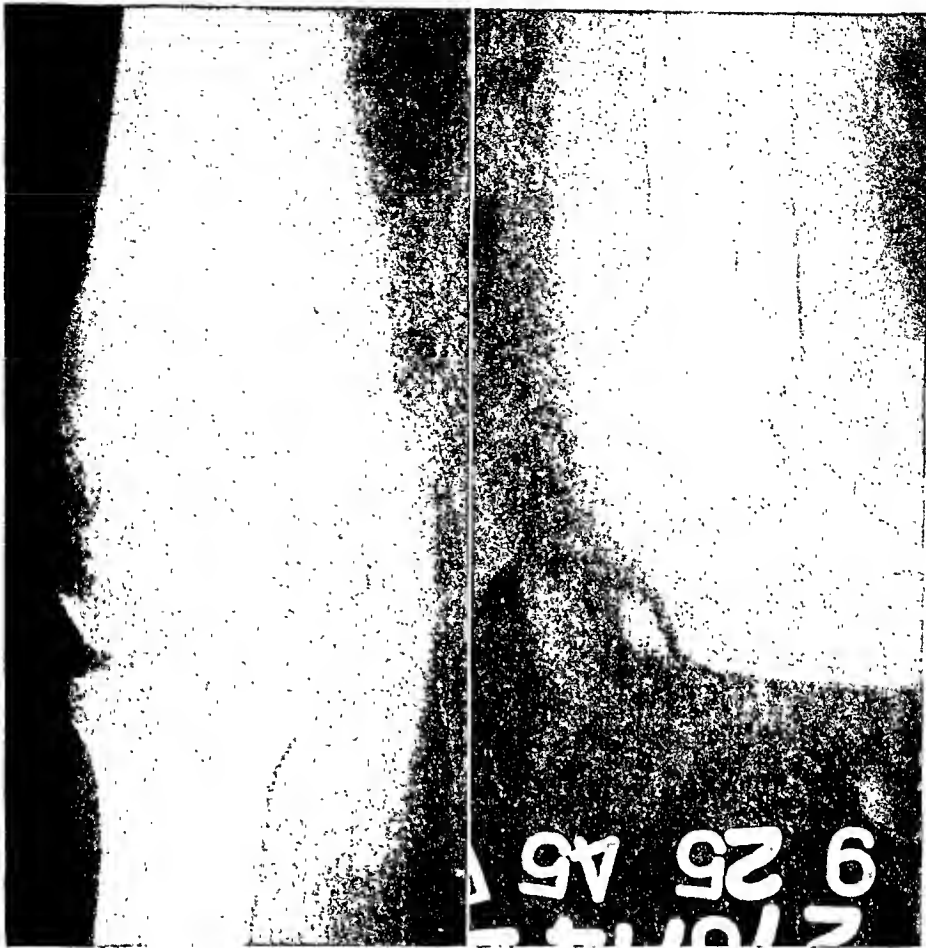


FIG. 3. D, lateral view after three days in traction. E, lateral view after seven days in traction and two days following manual correction of posterior displacement under anesthesia.



F

G

FIG. 3. F, and G, anteroposterior and lateral views three and one-half months after original injury. (The wire traction in this case was removed on the eighth day after injury and the elbow was immobilized further in a posterior molded splint until the twenty-fifth day after injury and then in a sling only for two weeks.)



H

I

FIG. 3. H and I, anteroposterior and lateral views one year nine months after original injury. (Result: full function, use and no deformity; complete recovery of motor and sensory functions of

There were thirty-nine patients treated by this method. The average age of these children was 7.7 years. Thirty-five of the patients appeared for treatment within twenty-four hours or less after injury; twenty-nine appeared within three hours. In four cases the duration was four, five and seven days, respectively. All but one of these four patients had one or more reductions attempted at other hospitals before coming to us. The majority of injuries were sustained in falls from a bicycle, trees, in the gymnasium or playground, etc. All of the cases showed marked displacement of the lower humeral fragment. In two cases the displacement was in an anterior direction, but in the remaining thirty-seven it was in the usual posterior direction with or without some lateral or medial shift. Six of the cases were compound supracondylar fractures.

Table 1 lists the cases under the reasons why Kirschner wire traction was resorted to and also lists the associated lesions where present. The case numbers in parentheses are additional listings where secondary causes were found for resorting to this method of treatment.

Reduction had been attempted in five patients before admission to this hospital. It was attempted in twenty-four cases by us prior to resorting to Kirschner wire traction and was considered unsuccessful or the reduction could not be maintained satisfactorily without compromising the circulation. In nine cases immediate insertion of the Kirschner wire was performed and subsequently followed by manipulative reduction and then by traction and suspension. Four of these were immediately put up in traction following operative débridement of their compound fractures. It has been stated elsewhere that if Kirschner wire traction and suspension alone does not give complete reduction in forty-eight to seventy-two hours, it may be advisable to give the patient a general anesthetic and manipulate the fragments again while still in traction. The traction should then be continued to maintain the reduction. This had to be done in twenty of the thirty-nine patients treated by this form of traction and resulted in marked improvement in position of the fragments, due partly to muscular relaxation and partly to diminished soft part swelling. (Figs. 2 and 3.) Operation was performed in only two uncontaminated cases of the entire thirty-nine. One was in a four-day old case with extreme swelling and bony displacement and

with a feeble pulse; the other was in a fresh case of five hours' duration with no palpable pulse. This latter patient when explored showed extreme spasm of the brachial artery where it was stretched over the sharp, projecting lower end of the humeral shaft fragment. This spasm persisted for at least one-half hour (under direct observation) after the fracture fragments were reduced and the offending disorder corrected.

In general the wire traction has been continued for an average of 13.1 days. The shortest duration of wire traction was for three days which was in the four-day old case which came to operation and was then discontinued. The longest duration for which it was used was twenty-eight days in one case with a separately displaced loose fragment. In the beginning the tendency was to use traction for a shorter period of time, but in the past eight to ten years it has been thought wiser to continue it for a longer period and therefore most of the more recent cases have remained in traction for two to two and one-half weeks. The best criterion for maintaining traction seems to be the presence of good callus formation as seen on lateral x-ray films. In three cases the Kirschner wire has pulled out from the bone due to imperfect original placement of the wire which engaged only the periosteum or a very superficial portion of the bone. It is important to have the wire at least  $\frac{1}{8}$  of an inch deep to the posterior cortex to prevent such a complication. If the wire should pull out and further traction is necessary, a new one may be reinserted under aseptic precautions. No serious complications have arisen from the wire traction, but there have been a moderate number of minor complications all of which have cleared up. Three patients developed wrist drop, but it was not definitely known whether these complications preceded the insertion of the wire or if they were the result of insertion of it. Posterior interosseus nerve weakness developed in one case. Partial anesthesia of the ulnar nerve developed in one case. All of these nerve complications cleared up completely over a period of several months. Three pressure sores with mild surrounding skin infections resulted from slipping of the wire laterally in the bone, allowing the traction yoke to come in contact with the skin; these cleared up with conservative treatment and none resulted in osteomyelitis or sinus tract infection.

After the Kirschner wire has been removed, we usually immobilize the elbow in mild flexion of 70 to 80 degrees in a posterior molded splint extending from the axilla to the metacarpophalangeal joints; a sling is also applied. The average duration of splinting following removal

When such a stage was reached (somewhere around two or three months) and progress seemed to be stationary, these patients were discharged from active treatment and given a follow-up date for three months hence. The parents were instructed to allow the child to

TABLE II

MISCELLANEOUS GROUP OF FIFTY-FOUR CASES IN WHICH KIRSCHNER WIRE TRACTION WAS USED

A. Dicondylar fracture of humerus.	2e, 3, 7, 9, 11, 14, 15, 17, 22, 23, 25, 27, 30, 32, 34, 35, 38, 39c, 40c, 41c, 42c, 46c, 49, 51, 52, 54
B. Fracture of surgical or anatomical neck of humerus.	1, 4c, 8, 10, 13, 19, 26, 28, 36, 37, 50, 52, 53
C. Separation of upper humeral epiphysis.	5, 12, 18, 47
D. Fracture of shaft of humerus.	6, 20,* 21, 24c, 43c, 44, 45c
E. Multiple fractures.	4, 10, 14, 19, 25, 28, 34, 35, (39), (40), 44, 52, 54
F. Miscellaneous.	16 — "Truck-swipe" fracture (25)—Fractured ribs, ruptured spleen, cerebral concussion 29 — Four-year old elbow dislocation (Post-op. traction only) 31 — Fracture of capitellum, trochlea, radial head and coronoid 33 — Twenty-four-day old subcoracoid dislocation of shoulder 48 — Thirteen-day old elbow dislocation unreduced (54)—Fracture pelvis and ankle; rupture of urethra

Case numbers are grouped under principal diagnosis; "e" following a number indicates that fracture was compound. Parentheses indicate additional lesions.

\* (Paget's disease of humerus)

of the wire has been 14.6 days. Following removal of the splint the arm is supported in a sling only for another ten days to two weeks. Active elbow exercises are frequently begun while the patient is still in traction and suspension and during the last week of wearing the splint. The splint is removed temporarily by the examining surgeon and the patient encouraged to exercise the elbow himself. No passive motion, weight carrying or forceful stretching exercises or heavy massage are permitted in any of these cases and none of them have developed myositis ossificans. We believe this is adequate proof that this form of active exercise (always within pain limits) can do no harm. These patients remained in the hospital on an average of 18.6 days and were carried on active treatment in the out-patient clinic or in the private offices for an average of 10.5 weeks. Maximum function was regained in the elbow joint in an average of 9.2 weeks. Even though some of these patients were slow to recover function, it was believed best not to try to hurry them. In a few cases it was necessary to tie up the patient's uninjured arm inside his shirt so that he would have to use the injured arm. Occasionally, the patient seemed to be impressed with the idea that visits to the clinic indicated that his condition was still serious and that he must do little or nothing to exercise or use the arm at home for fear of harming it.

use the arm at will and not to keep nagging him about using it. On return to this follow-up appointment most of these patients showed very marked improvement in function. Physiotherapy in the form of diathermy treatments given two or three times a week we believe to be definitely detrimental to functional recovery. It is all too frequent that the child relies upon such treatment to get him well and restore his elbow function while the remainder of the time he does nothing about it himself.

The results in this series of thirty-nine patients treated with over-head Kirschner wire traction have in general been excellent. The only residual deformity noted clinically has been a slight loss of the carrying angle at the elbow, or in some, a reversal of the carrying angle giving a mild to moderate "gun-stock" deformity, none of which has required operative correction. The average duration of follow-up for these thirty-nine cases has been five years and three months. Only two patients in the whole group have been followed for less than one year and each of these when last examined showed slight loss of elbow flexion, but no other impairment or deformity. At least five cases have been followed for ten years or longer. Of the thirty-nine cases thus followed fourteen were completely perfect from every standpoint (anatomic, functional and economic). Four more were completely perfect except for 5 to 15



FIG. 4. Female, age twenty-six years, with severely comminuted and badly displaced dicondylar fracture of humerus associated with complete radial nerve paralysis and partial ulnar nerve paralysis. Patient was admitted two days after injury (having received temporary treatment elsewhere) and Kirschner wire skeletal traction was applied immediately as shown in photograph above. Manipulation to overcome tendency of persistent posterior displacement of lower fragments was done on the fifth day. Traction was continued for six weeks following which patient was allowed home with arm in a protective splint and sling. The splint was removed daily for whirlpool baths and active exercises. A cock-up splint was worn on the wrist and electrical (galvanic) stimulation was given daily to the extensor muscles of the wrist and fingers. At the end of four months patient had recovery of active wrist extension but still lacked extension of the fingers at the metacarpophalangeal joints. Neurolysis was then performed on the radial nerve whose motor branch was found densely adherent to the bone at the healed fracture site; three months later the patient had recovered full motor power of this nerve. The ulnar nerve showed complete recovery within six weeks after the original injury; one year one month after injury patient had a range of motion in her elbow of 75 to 155 degrees and pronation and supination were complete. She returned to work as a registered nurse ten weeks after the original injury and has continued to work without handicap except for two weeks following the neurolysis operation.

degree loss of elbow flexion; eleven showed complete function and use, but some loss in the carrying angle only. The remaining ten cases showed some mild loss in function as well as some loss in the carrying angle.

In this particular type of supracondylar fracture in children it is the opinion of the author that no time must be lost in affecting reduction of the fracture and at the same time employing such treatment as will allow maintenance of the reduction without further impairment of the already embarrassed circulation. The method of Kirschner wire traction as described has accomplished this in thirty-nine cases of severe displacement *without a single case of Volkmann's ischemic paralysis having occurred*. Three of the patients thus treated had a threatening Volkmann's ischemia on admission, but this threat

disappeared shortly after over-head traction was instituted in each case.

*Group B. Miscellaneous Injuries.* In addition to the single group of children's supracondylar fractures cited above there has been a somewhat larger group of miscellaneous cases, fifty-four in number, likewise treated by Kirschner wire over-head traction at the Presbyterian Hospital from 1931 to 1945 inclusive. The wire traction has been the main form of treatment in twenty-six of these, but has also been used as a trial prior to operation in five others. In still another group of nineteen cases it has been used as a postoperative method of fixation which not only gave protection, but allowed at the same time active elbow exercise and hastened the disappearance of excessive edema and induration.



FIG. 5. L. H., female, age thirty-nine years; dicondylar fracture of humerus with comminution. This patient had been treated for five days in a "hanging cast" by another physician who referred her here with a note saying, "The hanging cast had not reduced the fracture and she was being referred for operation." It was decided in view of the extensive comminution that reduction could not possibly be accomplished and adequate internal fixation obtained by open operation without resorting to prolonged external splinting which would defeat the purpose of operation and lead to additional trauma and a good chance of a stiff elbow. Consequently, Kirschner wire skeletal traction was used and active exercises in traction were begun on the tenth day. Traction and suspension were maintained for six weeks. A and B, original lateral and anteroposterior x-ray views.

In this whole group there were twenty-six cases of dicondylar fracture of the humerus, seven of which were compound fractures; thirteen cases of fracture through the anatomic or surgical neck of the humerus; four cases of separation of the upper humeral epiphysis; seven cases of fracture of the shaft of the humerus, three of which were compound; thirteen cases of multiple fractures, and a miscellaneous group of seven cases with complicated or multiple injuries. (Table 11.)

In order to break this series down still further it has been divided into sub-groups according to the use of the wire traction. The first group in which it was used as the only method of reduction and immobilization consisted of twenty-six cases which come under the following diagnoses: dicondylar fracture of humerus (fourteen cases), fracture of shaft of humerus (one case), fracture of upper extremity of humerus, anatomic or surgical neck with or without tuberosity fracture (nine cases), separation

of upper epiphysis of humerus (two cases), and one twenty-four day old subcoracoid dislocation of the humerus. In all but two of these patients Kirschner wire traction was instituted upon the day of admission to the hospital either as a primary procedure or following an unsuccessful attempt to reduce the fracture manually under general anesthesia. The dicondylar fractures with marked comminution and displacement were put up in skeletal traction and only a few of these received subsequent manipulations in an attempt to improve the position of the fragments. Since all were adults they were kept in traction for an average of twenty-two days. Active motion was begun in traction at about one week and continued thereafter. (Figs. 4 and 5.) In others, where it was not begun until after the fourth week, the end results in respect to function in the elbow joint suffered as compared to those in which it was started earlier. It is believed that early active motion in traction helps to mold the comminuted fragments





FIG. 5. C, lateral view after five days in traction; D, anteroposterior view after two days in traction.

into a more favorable position to allow a greater range of motion, but this cannot be expected if the motion is not begun early and is postponed until four or five weeks after injury when new bony callus has "fixed" the fragments. None of these dicondylar fractures thus treated has resulted in bony or fibrous ankylosis. The poorest result had a range of motion of 40 degrees through an arc of 70 to 110 degrees, but she was able to use it in all her housework at the age of sixty-nine years when last seen three and one-half years after her injury. All but one of these cases has been followed from one to eight years and have in general at least 80 to 100 degrees of motion in their elbow joints in a useful range. One patient recovered full range of motion. The cases of anatomic or surgical neck fractures of the humerus were complicated by extreme displacement or with associated tuberosity fractures. These did not show remarkably good results, but perhaps better than could be

expected had they been treated as milder cases are with sling and swathe and early pendulum exercises, and certainly better than if they had been treated by means of abduction splints or plaster spicas. The two cases of separation of the upper humeral epiphysis did very well. One was followed for one and one-half years and had a perfect result at that time. The other moved to another state after four weeks, but was well on the way to a good result when last seen, and it is realized that this is not a late follow-up result. The over-head traction followed by manipulation maintained excellent reduction in both cases. The fracture of the shaft of the humerus obtained solid bony union, but we have no follow-up record on him later than thirteen weeks after his injury. The twenty-four-day old subcoracoid dislocation of the humerus was reduced manually after twenty hours of skeletal traction. No late follow-up is available, however.

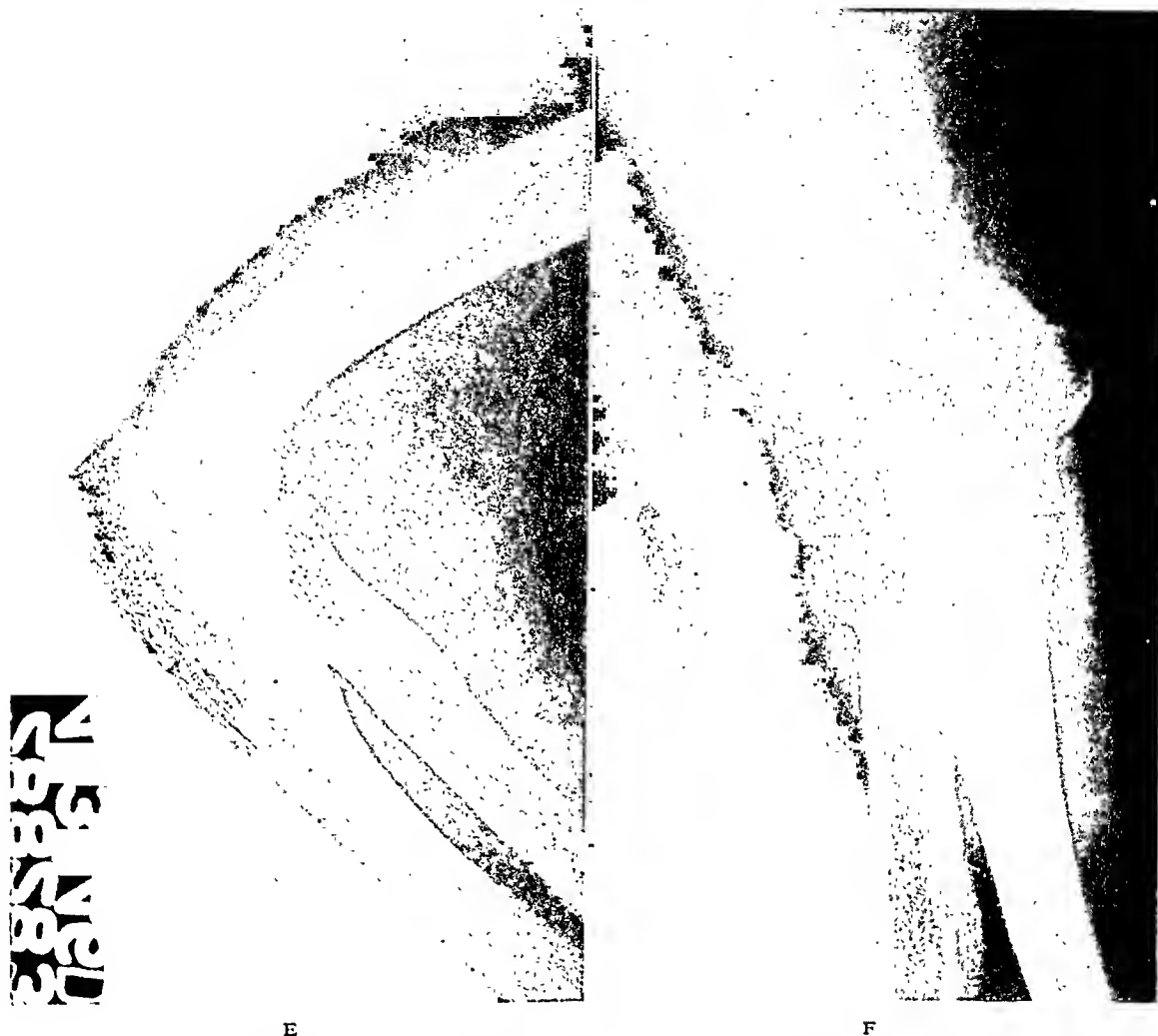


FIG. 5. E and F, lateral and anteroposterior views two and one-half months after original injury. Result: (one year seven months after injury) active elbow range 45 to 135 degrees; pronation and supination complete; no deformity, full use; strength excellent.

The second group in which Kirschner wire traction was used was in five cases as an anteoperative measure. Two of these were for condylar fractures with little comminution. The traction alone failed to give satisfactory reduction, so open reduction was resorted to after five and seven days, respectively. Good position was obtained and held by internal fixation with plate and screws and the late results were excellent. The remaining three cases (one surgical neck fracture, one separation of the upper epiphysis of the humerus, and one fracture of the shaft of the humerus) did not obtain satisfactory position from Kirschner wire traction, so consequently open reduction had to be performed.

The third group in which skeletal traction was employed mainly as a postoperative measure consisted of nineteen cases, twelve of which were complicated by compound wounds. Eight were condylar fractures, all but one being

compound. Débridement of the wound was performed in all cases and internal fixation was employed in two cases, but was later deemed an error owing to inability to fasten the fragments securely owing to extensive comminution. None of the cases resulted in infection of the compound wound or of the bone. The traction as used following operation was valuable in that it maintained satisfactory position of the fragments and allowed easy access to the wounds for dressing. (Fig. 6.) No other form of immobilization could have been so efficient in this respect. The late follow-up results in six of these cases were good to excellent. This is especially gratifying since four of these patients were over sixty years of age. Of three cases involving the upper extremity of the humerus, one anatomic neck fracture was operated upon and then placed in skeletal traction and obtained an excellent result; one compound surgical neck fracture became infected and obtained a poor

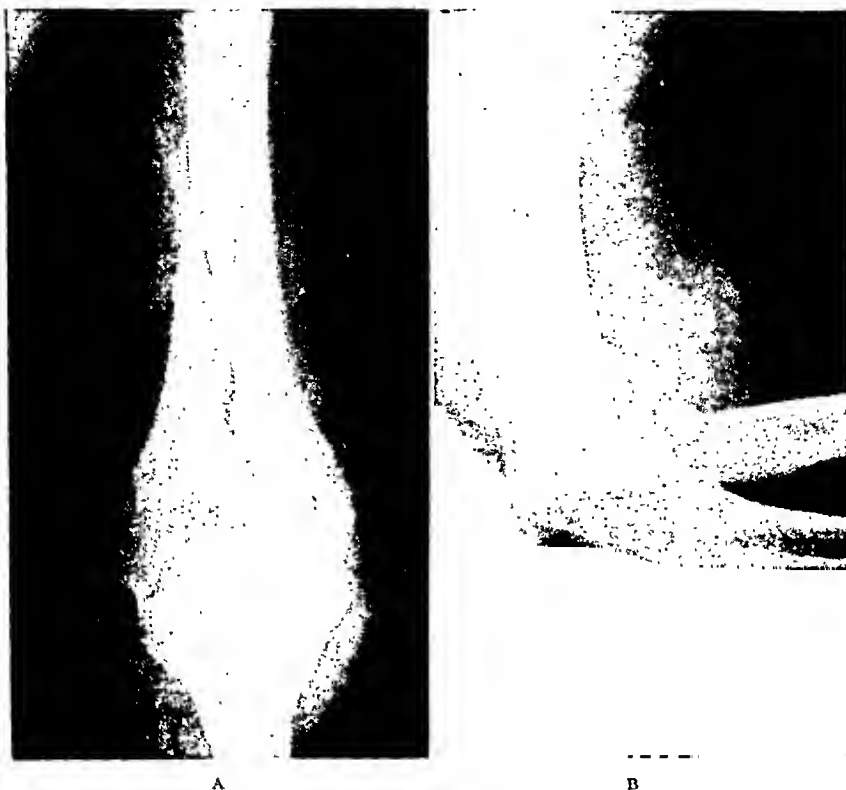
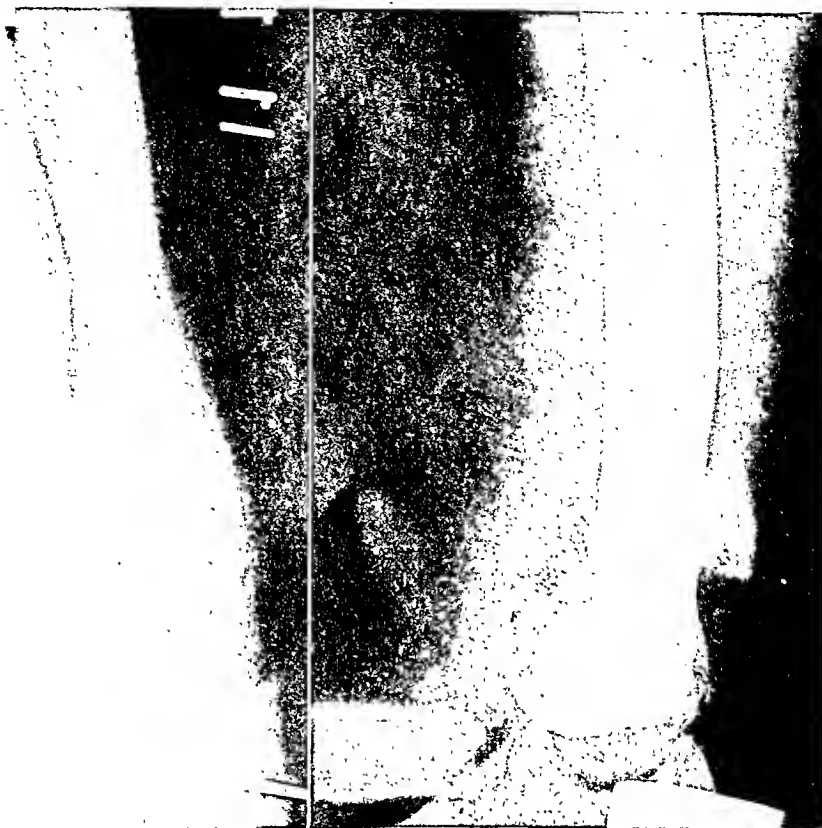


FIG. 6. N. B., female, age twenty-seven years; compound fracture of radial head and diendylar fracture of humerus from pistol wound. The wound was immediately débrided, the bullet was not removed, the radial head was excised and the arm was put up in Kirschner wire traction. The compound wound healed per primum. Mild active elbow exercises in traction were begun on the ninth postoperative day. Traction was removed on the thirtieth day postoperatively and the patient left the hospital four days later. At the end of five and one-half weeks after original injury the elbow range was 90 to 135 degrees; pronation was 50 per cent normal; supination was nil. The patient moved South immediately after this and did not return again until four years one month after her injury. Elbow range at this follow-up visit was 55 to 175 degrees; pronation was 90 per cent complete; supination was 40 per cent complete. (The limitation of supination was due to an old malunited Colles fracture and not to her elbow according to the patient.) She was able to carry on her full work as a housewife with difficulty. A and B, anteroposterior and lateral x-ray views of original fracture.

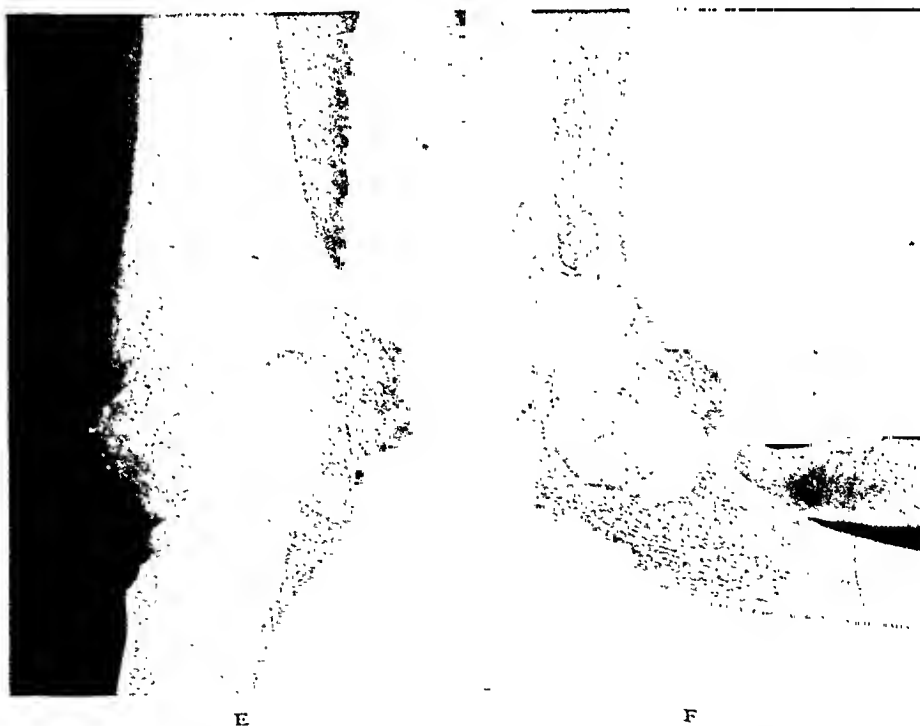
result, but this was not the result of the traction; one fracture-dislocation of the head of the humerus with associated brachial plexus injury (following an attempt at reduction by means of placing the heel in the axilla for countertraction at another hospital) subsequently came to operative removal of the dislocated humeral head, but obtained only a poor to fair result—certainly not attributable to skeletal traction.

Four fractures of the shaft of the humerus, three of which were compound, were treated after operation by wire traction. One of these was a gunshot injury with radial nerve paralysis and with marked comminution of the mid-shaft. It was impossible to use internal fixation

or any other form of traction. Union was slow but complete and with minimal deformity. Range of elbow motion seven and one-half years later was complete except for less than 10 degrees loss of full extension. Recovery of radial nerve function was complete by ten months after the original injury. A second patient obtained a good result by the end of six months, but died three months later of a cardiac condition, consequently there is no late follow-up record. In the third case of shaft fracture the humerus was plated and wire traction was used because of an associated fracture of the medial condyle of the humerus and obtained an excellent result except for 20 degrees



C D  
FIG. 6. C and D, same views in Kirschner wire traction.



E F  
FIG. 6. E and F, same views after four years one month.

limitation of full elbow extension. The fourth case was in a child in which débridement and closed reduction was done for compound fracture and skeletal traction employed to maintain reduction. A perfect result was obtained. Both of these last two cases have been followed for

longer than two and one-half years. A separation of the upper epiphysis of the humerus was operated upon in a seven-year old girl and followed by wire traction because she kept pulling off the skin traction employed immediately after operation. The wire traction was comfor-

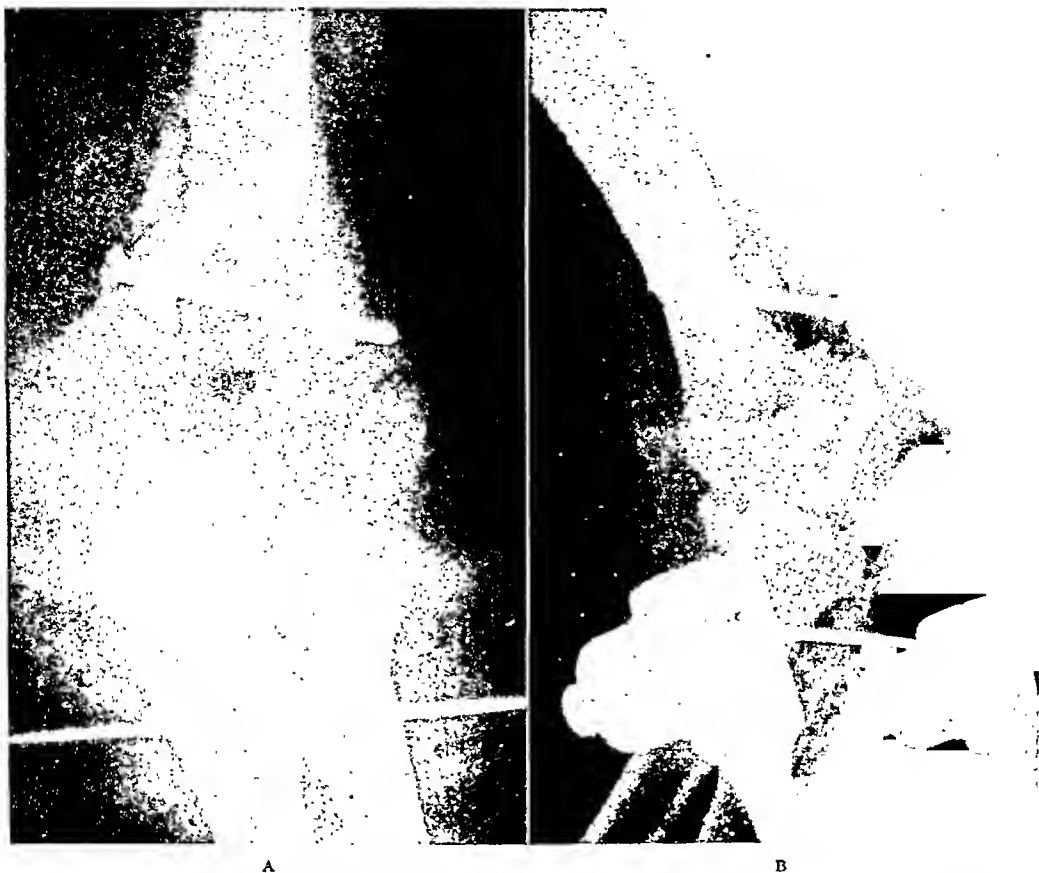


Fig. 7. E. K., female, age thirty-eight years; dicondylar fracture of humerus treated originally by Kirschner wire traction but satisfactory position of fragments was not obtained. Two days later open reduction was performed with internal fixation with plate and screws. Skeletal traction was continued for two weeks after operation and patient performed active elbow exercises while in traction. A and B, anteroposterior and lateral views in traction postoperatively showing excellent position of fragments. Late result four years later showed full function and use of elbow without any deformity.

table and maintained position accurately. Her late follow-up at eight and one-half years showed her to have full shoulder and elbow function, but a growth disturbance amounting to 7.5 cm. shortening of the humerus. Another severe injury of the "truck-swipe" variety with compound fractures of the humerus, radius and ulna at the elbow with partial loss of bony substance and with associated radial and ulnar nerve paralysis was put up in Kirschner wire traction (slightly more distally placed in the ulna) following operative débridement for lack of other means of immobilization. This patient had to have several subsequent sequestrectomies performed and subsequent plaster immobilization. His late result seven and one-half years after injury shows a semi-flail elbow, but one with a range of active (and strong) motion from 30 to 140 degrees. Another sixteen-year old girl following an arthroplasty operation for

an unreduced elbow dislocation of four years' duration was brought back into the hospital for Kirschner wire traction five weeks after operation in the hope of improving her motion range. She was a psychiatric case and very uncooperative and finally had to be returned to a mental institution. No late follow-up is available. One other case in which postoperative use of skeletal traction was employed was in a fifty-seven-year old woman with fractures of the capitellum, trochlea, radial head and coronoid. At operation the radial head was excised, as was also the capitellum and most of the trochlea. This patient obtained only a fair result after two years.

The fourth group of cases in which Kirschner wire traction was used both prior to and following operation consists of four cases. (Fig. 7.) Two of these were dicondylar fractures. The first did not show satisfactory reduction from the traction and was operated upon two days

later with good internal fixation obtained. After operation the traction and suspension were continued and the patient started on active exercises at two days. Traction was continued for thirteen days. The result at the end of more than four years was perfect in every standpoint except for five degrees of limitation of full elbow flexion. The second had a displaced fracture of the capitellum in addition to a dicondylar fracture. Traction did not reduce the former, and open reduction and replacement of this fragment was performed after one day. Traction was discontinued after four days and active exercises were begun on the twenty-fifth day. The result after four years was perfect except for 5 to 10 degrees limitation of elbow extension. The third case was a fracture of the shaft of the humerus, mid-third, in a bone involved with Paget's disease (osteitis deformans). The traction was used prior to operation for immobilization while blood studies and the patient's general condition were being evaluated. At operation the fracture was reduced and rigidly fixed internally with plate and screws. Traction was continued for four days after operation. The patient has been followed for eight and one-half years since operation and his result has been completely perfect from all aspects. The fourth case of this group was in a fifty-year old woman with an unreduced elbow dislocation of two weeks' duration. Attempts to reduce this had been tried on two occasions before she came to us for treatment. Swelling and induration were extreme and some visible callus was seen along the posterior aspect of the lower humerus on x-ray films. Her elbow was put up immediately in Kirschner wire traction and twenty-four hours later another attempt was made to reduce the posterior dislocation, but without success. Two days later open reduction was performed with difficulty. Traction was continued for only four days after operation. Active exercises were begun on the ninth day. Owing to the fact that this patient developed a marked myositis ossificans, she obtained a poor result from a functional standpoint. Flexion and extension were limited to approximately five to

ten degrees although pronation and supination remained complete. She had a strong and painless elbow one year and nine months after operation. The traction although it failed to assist in obtaining a closed reduction, could hardly be expected to do so in such a late case. The poor ultimate result may be attributed to the formation of myositis ossificans started by repeated attempts to bring about closed reduction and encouraged by open reduction at the wrong time (i.e. during the time when it had begun to appear on x-ray films). Such a patient should have been operated upon immediately after the first attempt at closed reduction was found to be unsuccessful.

#### SUMMARY

1. A series of ninety-three cases of elbow and upper arm injuries treated by means of overhead traction and suspension by means of a Kirschner wire in the olecranon has been discussed in detail and an attempt to evaluate the results of the method has been made.

2. In the first group of thirty-nine cases of supracondylar fracture of the humerus in children the method has been ideal for obtaining and maintaining reduction and in overcoming serious threat to the circulation. It has made it practically unnecessary to perform open reduction for this fracture and once the traction was instituted, all fear of Volkmann's paralysis has been dispelled. Not a single catastrophe of this nature has resulted in 402 cases of all types of supracondylar fractures treated over a period of sixteen years.

3. In another group of fifty-four cases of miscellaneous fractures, etc., in the region of the elbow and upper arm the method has been found especially useful in the treatment of badly comminuted dicondylar fractures of the humerus and in compound fractures of the elbow region or shaft of the humerus. For injuries at the upper extremity of the humerus the use of this form of traction has a limited range. In dicondylar fractures without comminution its greatest use was as a preoperative and postoperative measure.



# FACTORS WHICH MODIFY THE CHOICE OF ANESTHESIA IN THE SURGERY OF TRAUMA

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WORLD War II demonstrated the value of modern technics of anesthesia and surgery in handling the severe traumatic injuries involving the vital organs and structures of the human body. Since the advent of the specialty surgical teams during the war, experiences gained in surgery and anesthesia have been applied by the surgeon and anesthesiologist to the many civilian, industrial, home and traffic accidents in the surgery of trauma. One lesson learned has been that the proper handling of anesthesia plays an important rôle in the condition of the patient and the outcome of the operation. All cases in the surgery of trauma are initially emergency operations, but for the purpose of reconstruction or plastic repair may be secondarily elective operations. In these cases there are many factors which modify the choice of anesthetic agents and methods of administration. There are those due to the general condition of the patient and others which are the direct result of trauma or incidental to trauma.

In this discussion it will be shown that the choice of an anesthetic agent is modified more by the analysis of the complicating factors rather than the proposed surgery. For example, a patient with a rupture of the liver and in shock from hemorrhage cannot be given a high spinal anesthesia, as an elective abdominal operation would receive, but would be treated for shock first and then be given regional anesthesia (field block with 1 per cent novocaine) supplemented with cyclopropane-oxygen.

Let us first consider the more important factors entailed in the general condition of the patient. These are the age, blood pressure, respiratory, cardiac, trauma in the presence of thyroid disease, renal and hepatic factors.

The very young and very old are two age groups which deserve special consideration. The metabolic rate in both groups are so reduced that they cannot tolerate depressing and toxic drugs for pain relief. In operations above

the diaphragm, cyclopropane-oxygen gives the safest control for these extremes of age in the presence of shocking injuries. Below the diaphragm regional anesthesia combined with cyclopropane-oxygen is indicated in these individuals if debilitated from shock or disease. If the patient is in good physical condition, these operations are best performed with spinal anesthesia with or without cyclopropane-oxygen. In surgery of the extremities in the senile as amputation of the lower extremities, refrigeration anesthesia may be employed to good advantage. Regional anesthesia in the senile may often be sufficient for the large majority of operations in either upper or lower extremities, especially in severe trauma to the upper extremities, as compound fracture of the humerus, or severed tendons of the hand or wrist.

If a high blood pressure is recorded, it should be determined whether the cause is of a psychogenic or pathologic origin. Usually a functional type of hypertension responds to preliminary medication, whereas the hypertension of pathologic origin remains high in spite of the action of the basal drugs. The hypertensive patient tolerates both general and spinal anesthesia well, but does not tolerate a fall in pressure from drug action. For this reason, a vasoconstrictor drug as ephedrine or neo-synephrine helps to maintain the patient's preoperative blood pressure level. Hypotension is usually the result of shock from trauma or loss of blood, although it may be of a functional nature. If the hypotension is the result of trauma, the patient will be treated for shock prior to surgery. Even in the presence of moderate shock or hypotension of debilitating disease as tuberculosis, the vasoconstrictor drug, neo-synephrine, in a three minimum dose and repeated for three doses if necessary will maintain or raise the blood pressure. If this fails to correct the condition, fluids and blood transfusion should be administered.

In the presence of respiratory tract disturb-



ance, for operations of the upper body regional anesthesia should be employed as much as possible, with intubation of the trachea under topical cocaine for the administration of oxygen or cyclopropane-oxygen. For operations in the lower body or extremities, spinal anesthesia is indicated.

Bronchial asthma presents a real problem. Morphia and the barbiturates are contraindicated because of the dangers of precipitating marked bronchial spasms. Chloral hydrate or paraldehyde as a preliminary is tolerated by the asthmatic. Atropine is combined to this basal hypnotic drug to allay vagal reflexes and dry secretions. Nitrous oxide-oxygen-ether is given cautiously because of the retarded induction caused by the slow absorption of the anesthetic in the alveoli due to the spastic bronchi. Oxygen must be kept at a high concentration at all times. If extreme bronchial spasm is present, helium 79 per cent and oxygen 21 per cent should be added to the mixture to facilitate the passage of the gases through the spastic bronchi. In external chest operations regional anesthesia with oxygen should be used. In intra-abdominal and lower extremity operations, spinal anesthesia with oxygen is employed. In traumatic conditions of the respiratory and upper gastrointestinal tract, intratracheal anesthesia with cyclopropane-oxygen under pressure prevents collapse of the lungs in the presence of open pleura and allows for positive pressure with oxygen and aspiration of secretions from the lower respiratory tract.

In severe cardiac disease, special care should be taken to administer the minimum of anesthetic agent and a maximum of oxygen concentration throughout the operation. Regional anesthesia supplemented with cyclopropane and oxygen is to be preferred. If severe arrhythmia of circulation develops, a shift to ether and oxygen in the closed system should be made.

In the cardiac patient, operations involving the extrenal thorax or upper extremities may be best handled with pentothal sodium  $2\frac{1}{2}$  per cent supplemented with 50 per cent nitrous oxide-oxygen which may be reinforced with cyclopropane-oxygen intermittently rather than forcing either the intravenous agent or nitrous oxide. This will provide a high concentration of oxygen throughout the operation and allow the patient to be awake with complete control of reflexes at the end of the operation. In intra-

pleural or transthoracic operations intratracheal administration of cyclopropane or ether with high oxygen concentration is indicated. The intubation is done under topical pontocain in  $\frac{3}{10}$  of 1 per cent solution. In the presence of the more severe cardiac disorders, regional anesthesia supplemented with oxygen intratracheally should be employed. In operations below the diaphragm, balanced continuous spinal anesthesia with minimum doses of spinal agents combined with cyclopropane-oxygen gives maximum duration and relaxation. In the lower extremities, spinal anesthesia with a very low dose of the agent combined with the oxygen is sufficient for most operations.

Patients with non-toxic conditions of the thyroid gland present no special problem in anesthesia for the surgery of trauma; but emergency cases with toxic thyroid, however, especially when complicated with cardiac insufficiency, require very careful consideration. The patient treated today with thiouracil preparations demonstrates less toxic signs and responds well to cyclopropane-oxygen anesthesia for upper body operations and spinal anesthesia for operations below the diaphragm. If there is a large degree of toxicity present, the patient should be controlled principally with regional anesthesia supplemented with 50 per cent nitrous oxide-oxygen in operations above the diaphragm. If this technic is not favored in operations above the diaphragm, sodium pentothal  $2\frac{1}{2}$  per cent solution for induction may be supplemented with local field block with 1 per cent procaine and cyclopropane-oxygen administered. Below the diaphragm operations are best performed with spinal anesthesia. In the patient with thyrotoxicosis, the chief dangers are from sudden cardiac collapse, which is believed to be due to an abnormal stimulation of the sympathetic system and an overproduction of adrenalin. Spinal anesthesia in these cases has proved to be of value in preventing this complication evidenced by tachycardia and hypertension in these patients during operation, by depressing the sympathetic system, especially the sympathetic plexus controlling the adrenal glands. Intratracheal intubation is employed only in the very toxic thyroid patient or in the presence of dislocation of the trachea by tumor with respiratory tract obstruction.

If kidney function is insufficient from renal disease, the toxic volatile anesthetics and bar-

biturates are contraindicated. Cyclopropane-oxygen and regional anesthesia in the upper extremities and above the diaphragm and spinal anesthesia or regional below the diaphragm prevent any depression of renal function.

In liver disease the chief contraindication is any anesthetic agent which causes liver damage as ether, chloroform, ethyl chloride or avertin. These patients tolerate gas oxygen well for operations above the diaphragm and spinal anesthesia with minimum doses supplemented with cyclopropane-oxygen for operations below the diaphragm.

With modern control of diabetes by insulin and diet the diabetic patient is able to tolerate any of the anesthetics of choice best adapted to the existing traumatic conditions. Spinal anesthesia should be used for all operations below the diaphragm and lower extremities. The more toxic agents as ether which depress the vital organs should be eliminated as much as possible. Cyclopropane-oxygen is a good substitute for ether, especially when supplemented by regional anesthetic agents.

The factors influencing the choice of anesthesia for the patient in the surgery for trauma which are the direct result of trauma or incidental to trauma are coma, alcoholism, excitement, shock from trauma to the central nervous system, tissue damage and hemorrhage; foods, liquids, or blood in the stomach; and respiratory obstruction from extrinsic causes, as external injuries to the neck, oral cavity, chest, spinal region, and intrinsic causes as spasms of upper or lower respiratory tract from foreign body or other reflex causes.

A careful history should be taken on the unconscious patient from the most available sources combined with a complete physical and laboratory examination. Here one must differentiate between trauma to the brain or disease of this organ, coma due to diabetes, kidney, or circulatory diseases, alcoholism or other drug poisonings. In comatose patients with brain or respiratory tract involvement, intratracheal intubation under topical pontocain in  $\frac{3}{10}$  of 1 per cent solution should be instituted for the administration of sufficient oxygen to prevent hypoxia and to perform positive pressure when indicated and also to allow for frequent aspiration of secretions.

The alcoholic will require gastric lavage and the introduction of a Levine tube through the

nasal passage which is left in the stomach for drainage. Care should be taken not to administer morphia or ether as the brain is already edematous. This would increase the danger of acute cerebral edema and immediate death or the danger of delirium tremens postoperatively. In operations above the diaphragm, rectal paraldehyde 15 to 30 cc. per 100 pounds of body weight supplemented with gas-oxygen (cyclopropane) intratracheally will provide sufficient anesthesia and prevent the cerebral or respiratory complications so commonly seen with the use of morphia or ether in these patients during operation and postoperatively. In operations below the diaphragm and the lower extremities of the alcoholic patient, spinal anesthesia furnishes the safest pain relief and relaxation for surgery. If the patient is uncontrollable with this technic, spinal anesthesia should be supplemented with cyclopropane-oxygen.

The emotionally imbalanced patient requires encouragement and reassurance together with sufficient basal narcosis to allay fear and apprehension. Intravenous morphine and scopolamine may be given immediately preceding anesthesia for basal effect. Intravenous pentothal sodium  $\frac{1}{2}$  per cent solution will give a quick induction for gas-oxygen anesthesia. If spinal anesthesia is employed, it may be supplemented with cyclopropane-oxygen before or after the spinal is administered. This is especially applicable to uncontrolled children. If cyclopropane is kept at a very low concentration, the patient is kept asleep during the whole operation but will be conscious immediately postoperatively.

Before anesthesia is considered for the patient in shock, the cause, type and degree of shock should be determined. If the shock is severe, the operation is postponed. Fear and apprehension should be alleviated early by the use of hypnotics and morphia. If the hemorrhage is external, it should be brought under control and the treatment of shock should be instituted with supportive therapy as soon as possible. Intravenous fluids should be started at once with glucose 5 to 10 per cent in saline immediately followed by whole blood or plasma as indicated as soon as it is obtainable. To relieve the complication of hypoxia from loss of hemoglobin, oxygen should be immediately administered. The most controllable method of pain relief in cases of shock above the

diaphragm, is the administration of cyclopropane oxygen with intratracheal intubation introducing the tube under topical pontocain in  $\frac{3}{10}$  of 1 per cent solution. Wherever possible, regional anesthesia should be employed for speed and safety in the care of the patient in severe shock. This allows for the administration of oxygen to support the patient in this collapsed state. If it is necessary, the regional anesthesia may be supplemented with cyclopropane-oxygen, keeping the oxygen at a maximum concentration. However, if after the treatment of the shock condition the patient responds favorably and the blood pressure is stabilized above 100 mm. systolic, spinal anesthesia in minimum doses may be balanced with a light concentration of cyclopropane-oxygen in operations below the diaphragm and lower extremity operations.

The patient whose stomach contains food, liquid or blood should not be subjected to a general anesthetic for major operations. If general anesthesia is imperative, gastric lavage should be performed at once and a Levine tube left in the stomach for drainage. Any patient with stomach contents or suspicion of the same, should be intubated with a balloon-catheter before any general anesthetic is administered. The tube may be introduced before induction of the general anesthetic—under topical pontocain in  $\frac{3}{10}$  of 1 per cent solution. If the patient has been given a general anesthetic and vomits during induction, the anesthetic should be discontinued at once, and the head of the patient carried over the side of the operating table in Trendelenburg position. Vomiting should be initiated and the patient allowed to regain consciousness to the point of a cough reflex in order to expell any foreign material from the lower respiratory tract. The mouth and throat should be thoroughly aspirated before reinduction of the anesthetic is instituted. If vomiting takes place during the operation and there is need for continuing the anesthesia, an intratracheal tube should be passed which allows aspiration of the bronchi with a suction catheter. The intratracheal tube is left in place and the anesthesia is continued after carrying the patient to a deeper plane to avoid possibility of more vomiting. Immediately after operation, bronchoscopy should be performed with aspiration of the lower respiratory tract. To avoid dangers of vomiting in these cases spinal anesthesia should be em-

ployed in all operations below the diaphragm and lower extremities. When general anesthesia is imperative for minor surgical emergencies such as reduction of simple fractures or painful dressings, it may cause serious complications in the patient with a full stomach. For these emergency procedures the safest and the quickest reversible method of anesthesia is the administration of nitrous oxide-oxygen by the supersaturation technic. Without the use of any basal drug the patient is induced with a high concentration of nitrous oxide to a pre-asphyxial state, without allowing cyanosis, stertorous breathing or convulsive twitchings. At this point oxygen is added in sufficient quantity to maintain the patient in first plane of third-stage anesthesia. This level of anesthesia controls all tissue reflexes involved in these minor surgical procedures. The patient returns to normal reflexes and consciousness after the first few inhalations of oxygen and the removal of the nitrous oxide. If vomiting should occur, the protective reflexes of the respiratory tract are present before the vomiting reflex is initiated.

Respiratory obstruction is the most critical complication which can occur during anesthesia. Before an anesthetic is chosen in any emergency operation the cause of obstruction to the respiratory tract must be determined by close examination. Nasopharyngeal, oral, laryngeal and lower respiratory tract examination with laryngoscope and bronchoscope should be performed. Extrinsic and intrinsic causes of respiratory obstruction must be diagnosed before the administration of anesthesia. In a case of severe respiratory obstruction with impending death tracheotomy should be performed immediately with the introduction of a suction catheter for aspiration of the trachea and the administration of oxygen through another catheter for resuscitation of the patient. The facilities for immediate administration of a general anesthetic whether inhalation or intravenous should be available to control the patient's reflex as soon as the patient is revived and to carry out the surgical procedure. For operations above the diaphragm with respiratory obstruction, inhalation anesthesia preferably with cyclopropane-oxygen should be administered intratracheally. If the obstruction is not severe and can be controlled, intravenous pentothal  $2\frac{1}{2}$  per cent solution may be used with nasal catheters in each nostril, one being attached to a gas-oxygen

machine for the administration of nitrous-oxide-oxygen 50 per cent. Injuries to the neck and chest complicating the normal respiratory tract function should be anesthetized with intratracheal cyclopropane-oxygen; or if respiratory obstruction is severe, the inhalation anesthesia should be administered through a tracheotomy tube. Where intratracheal anesthesia is being employed to relieve a severe respiratory obstruction, the intratracheal tube should be left *in situ* postoperatively until the cause of the respiratory obstruction is relieved. If the obstruction persists so as to endanger the life of the patient, a tracheotomy tube should be inserted as the intratracheal tube is being removed in order to preserve a patent airway. Below the diaphragm, operations complicated with respiratory obstruction are best anesthetized with a minimum of spinal anesthesia combined with intratracheal cyclopropane-oxygen. In operations on the lower extremities, a low dose of spinal anesthesia supplemented with oxygen will prevent any serious accident in the presence of respiratory obstruction. Regional anesthesia supplemented with light cyclopropane-oxygen is indicated when other technics are contraindicated.

Many of the factors which modify the choice of an anesthetic for emergency cases are to be found in the elective operations in the surgery of trauma, except that the condition of the patient is usually better after supportive and resuscitative treatment following the preliminary emergency operation. In the elective cases it is possible to prepare the patient more completely with basal drugs and the patient is able to tolerate a more complete anesthesia. The elective case differs from the emergency case in that the surgery is of a more reconstructive nature and requires a choice of agent to obtain a longer lasting anesthesia. For example, instead of a regional block of a nerve or a nerve plexus which may wear off in the course of an hour, the patient will be able to tolerate a total or continuous spinal anesthesia for an operation below the diaphragm or a lower extremity operation lasting several hours, or a choice of any of the general anesthetic agents for upper extremity procedures may be made best suited to the patient.

In operations about the head, if the patient's condition is not too serious, intravenous pentothal 2½ per cent solution supplemented with 50 per cent nitrous oxide-oxygen is indi-

cated. This technic may be employed for either long or short operations involving the brain or external tissues of the head, nose and throat, and oral operations. The anesthesia of election for short operations about the face, or oral cavity, which are not going to interfere with respirations, is pentothal sodium 2½ per cent supplemented by nitrous oxide-oxygen with the double catheter technic employed. A nasal catheter is introduced in one nostril for exchange of gases and exit of any excess secretion and another is inserted in the other nasal passage for introduction of nitrous oxide-oxygen—50 per cent mixture. In the oral cavity the surgeon packs gauze back to the two nasal catheters to prevent blood or foreign bodies from passing into the oropharynx. In fractures of the jaw, regional block anesthesia requiring wiring of the jaws prevents the dangers of aspiration of vomitus which is likely to complicate general anesthesia, but more seriously to cause atelectasis and massive collapse of the lungs. In external chest or abdominal and upper or lower extremity operations as skin grafts or burns or other denuded areas, cyclopropane-oxygen or sodium pentothal 2½ per cent solution supplemented with 50 per cent nitrous oxide-oxygen will be sufficient for control of pain.

In abdominal operations if the patient's condition warrants it, spinal anesthesia with minimum doses of the agents supplemented with cyclopropane-oxygen provides a safe control. In long abdominal operations continuous spinal anesthesia with minimum doses of the agent balanced with cyclopropane-oxygen provides satisfactory anesthesia. If the patient is in serious condition, spinal anesthesia is contraindicated and local infiltration with 1 per cent novocaine supplemented with cyclopropane-oxygen provides sufficient relaxation for this type of patient. With either technic to complete relaxation curare may be administered intravenously to good advantage.

In operations on the spine two considerations are of most importance. First is the prevention of pressure on the abdomen interfering with diaphragmatic excursion by placing a pillow under the pelvis and the chest. Second, in cases requiring casts, as spinal fusions or upper vertebral operations intratracheal anesthesia should be used leaving the intratracheal tube *in situ* until the patient is conscious in order to prevent laryngeal or bronchial spasm by removal of the tube before the patient is in control of his own

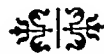
reflexes. Operations on the upper extremities with patients in poor condition are best done with brachial plexus block, whereas operations in the lower extremities are best performed under low dose spinal anesthesia. Operations on the femur in senile patients as hip-nailing or plating of spiral fractures of the shaft of the femur are best done with very low dose spinal anesthesia supplemented with oxygen. In the presence of circulatory insufficiency or cardiac disease, oxygen should always be administered. In operations of the lower extremity in little children, as closed reduction of fractures or shaft of femur, spinal anesthesia is an ideal technic, as it gives complete relaxation, with sufficient duration for manipulation, fluoroscopy and x-ray of the bone, without disturbing the patient in any way. Three-year-olds with fracture femurs have received sufficient premedication, then been entertained by their nurse with toys during a reduction application of apparatus and x-ray, and the whole thing repeated because of over-reduction of the fracture with the spinal anesthesia lasting well over three hours.

#### CONCLUSIONS

In conclusion, in the majority of cases general anesthetics, preferably cyclopropane-oxygen and pentothal sodium, are used for operations above the diaphragm which will allow a high oxygen concentration to be administered. In the patient in poor condition,

regional anesthesia for upper extremities is chosen. In the abdomen and lower extremities spinal anesthesia is indicated with the exception of a very bad risk patient when regional and gas-oxygen anesthesia are employed. Sodium pentothal as a total anesthetic is to be condemned as it produces a profound depression of respiration in order to control pain and reflexes, together with the difficulty of keeping an even level of anesthesia, also, there is the danger of vomiting in the emergency cases. Curare is used as an adjunct to a light inhalation anesthesia or pentothal sodium in combination with gas and oxygen and to facilitate the introduction of the intratracheal tube to complete induction if respiratory tract spasm is in excess. Curare is employed where a reduction of the general anesthetic agent is necessary to prevent overconcentration in the patient in poor condition or the general anesthetic is not sufficient to control the reflexes of respiration or the abdomen.

From the beginning to the end, the safety and well being of the patient in the surgery of trauma is of supreme importance. First, the complete knowledge of the patient's condition, secondly, the knowledge of the drugs used in anesthesia and their action on the patient in the presence of disturbed physiology and pathology, and last but not least, the efficient selection and administration of these drugs to obtain the most satisfactory results during and after operation are important requisites.





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## Editorial

### HYPOSPADIAS—WHEN TO OPERATE

THE physiologic functions of the penis are concerned with urination and insemination. In hypospadias the act of urination can be performed but is often retarded by congenital stenosis of the hypospadiac meatal orifice which is extremely common. Consequently, the initial therapeutic step must necessarily be the establishment and maintenance of free urinary drainage by (1) meatotomy, (2) dilation with sounds or (3) both. Balanitic or glandular hypospadias is the mildest variety of this anomaly and there is no interference with insemination. But in the other forms of hypospadias in which the meatus opens more proximal, insemination cannot occur for anatomic reasons and correction of the reproductive defect is equally as important as the cosmetic improvement.

According to personal autopsy data, based on a study in 12,280 children, some variety of hypospadias affects one in every 1,100 newborn males, is usually first recognized by the obstetrician, is further "watched" by the pediatrician and ultimately comes to the attention of the surgeon be he general, plastic or urologic. The anomaly results from failure of the urethral gutter to fuse from behind forward and may be classified as glandular or balanitic, penile, penoscrotal, perineal or pseudo-vaginal according to the location of the

ectopic meatus. The balanitic variety rarely merits surgical treatment except to insure a wide open meatus, and attempts to "pretty up" the end of the penis in these cases is indeed meddlesome surgery.

At present a vast confusion of notions concerning when to begin treatment prevades the thinking of both the medical and surgical advisors of the hypospadiac patient. Text books, both surgical and pediatric, advise operations at ages ranging from four years to puberty. Unfortunately the vain hope that the child will outgrow the malformation too frequently sways therapeutic suggestions. One of the most important components of the malformation is the congenital chordee brought about by the fibrotic ventral band which extends from the region of the normal meatus well back to the division of the penile corpora cavernosa. This structure is the congenitally hypoplastic fibrotic corpus spongiosum or its sclerotic remnants, growth of which does not keep pace with that of the penis; thus is formed a G-string which in turn causes downward bowing of the organ. This chordee is particularly marked when erection occurs. The penis thus restricted can grow neither straight nor to normal size until the ventral fibrotic cord is removed and the longer the growing organ remains bent downward upon itself, the less susceptible to surgical correction



will the deformity be. It is utterly foolish to make a new urethra in a penis thus firmly incurvated. Direction of the urinary stream will be exceedingly difficult and insemination impossible even though a patent new urethra is achieved. *It is advised, therefore, that the initial operation to correct the congenital chordee be carried out when the boy is nine to twelve months of age.* At this operation the hypoplastic fibrotic corpus spongiosum or G-string is widely excised from the region of the frenum to as far back as any restricting tissue can be palpated. Often this will be 2 to 3 cm. proximal to the ectopic meatus. The excision must be sufficient to permit the penis complete freedom of movement in all directions and without abnormal tension at any point along the shaft.

The construction of the new urethral canal proper is performed when the boy is five, six or seven years old and the penis is relatively straight. The urethroplasty proper must be delayed until penile and scrotal growth affords sufficient tissue with which to make the reconstruction which must be free of tension and accomplished with precise hemostasis.

In the interim between the initial operation and the subsequent urethroplasty, the chief concern is the maintenance of a normal urethral caliber and a widely open hypospadiac meatal orifice.

Regardless of the type of urethroplastic procedure the surgeon proposes ultimately to use, it is well to preserve as much of the prepuce as possible. Often the writer has been happy indeed to have this tissue for covering over large ventral cutaneous defects when the final urethroplasty is performed—whether one employs the Om-bredanne procedure or not. Fortunately this precaution is now observed in increasing numbers of hypospadiac males subjected to ritualistic circumcision; only a token piece of tissue is taken and a generous prepucial hood is left for subsequent plastic utilization as required.

In summary, if the initial operation in the surgical treatment of hypospadias is performed by the time the boy is one year old, his penis will be given maximum opportunity to grow straight and to relatively normal size, the basic prerequisites to subsequent successful urethroplasty.

MEREDITH F. CAMPBELL, M.D.



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# Case Reports

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## PERFORATING WOUND OF PERICARDIUM\*

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WOUNDS of the chest involving the heart and great vessels are not uncommon. One type, penetrating wounds, are usually caused by stabbings, gunshot wounds or injuries to the chest in which a rib penetrates the pericardial cavity. If the victim does not succumb quickly, there is a chance of repairing the injury and of survival. With greater interest in these injuries, the immediate availability of blood in emergency and by decreasing the time between injury and operation, the chance of survival has improved. More of these operations are being performed successfully each year. Another type, compression wounds of the chest due to direct crushing force, are seen mostly in industry and highway accidents. They cause a rupture of one of the auricles or one of the large vessels with heart tamponade and rapid death. Surgery offers very little for these injuries.

The case to be reported is of interest for several reasons: The wound was caused by a mechanical pencil which penetrated the pericardium bruising the heart muscle. This type of injury has not previously been reported. The deportment of the injured person was interesting. The findings on admission and at operation were also unusual.

### CASE REPORT

G. A., a fifteen year old High School student, was running for a bus on icy pavement on February 5, 1947, when he slipped and fell. He was carrying a mechanical pencil in the left chest pocket of a sweater. He picked himself up and continued to board the bus without any

knowledge of serious injury. However, when inside the bus, he noticed a pain in the left chest over the heart and found that the pencil had penetrated his chest and was sticking out through his clothing. Several of his fellow students immediately tried to pull the pencil out but he requested that it be left in place until medical help could be obtained. An ambulance was called and he was removed to the Newark City Hospital.

On admission, the clothing was cut from around the protruding pencil. It was found to lie in the fifth interspace 2 inches from the midline just medial to the left nipple and pointed in an upward direction. About 4 cm. of the pencil protruded from the chest. (Fig. 1.) The protruding portion was oscillating regularly with each beat of the heart. The patient was apparently in good condition but was apprehensive. The pulse was 88; blood pressure 120/100. He was given  $1\frac{1}{4}$  gr. of morphine sulfate hypodermically and 1,500 units of tetanus antitoxin.

He was removed from the emergency room to the Surgical Service of Doctor Royal A. Schaaf and preparations were made for operation. On admission to the ward a recheck showed the lung fields to be clear. There were no adventitious sounds. The heart sounds were normal except for slight diminutions in intensity. Five minute checks of his pulse, respirations and blood pressure showed no change. He was typed for transfusion. A massive penicillin dose was administered. An x-ray showed the radio-opaque foreign body, one end of which was on the level with the inferior margin of the anterior third of the left third rib; the other end was just medial to the anterior end of the left fourth rib. The intrathoracic portion extended cephalad and measured approximately 10 to 12 cm. The foreign body had

\* From the Surgical Service of Dr. Royal A. Schaaf, City Hospital, Newark, N. J.



FIG. 1. Preoperative picture of pencil protruding from chest wall.  
FIG. 2. Removing the fourth rib; pencil visible in operative wound.  
FIG. 3. Chest cavity opened.  
FIG. 4. Same as Fig. 3; haziness of pencil due to heart action.

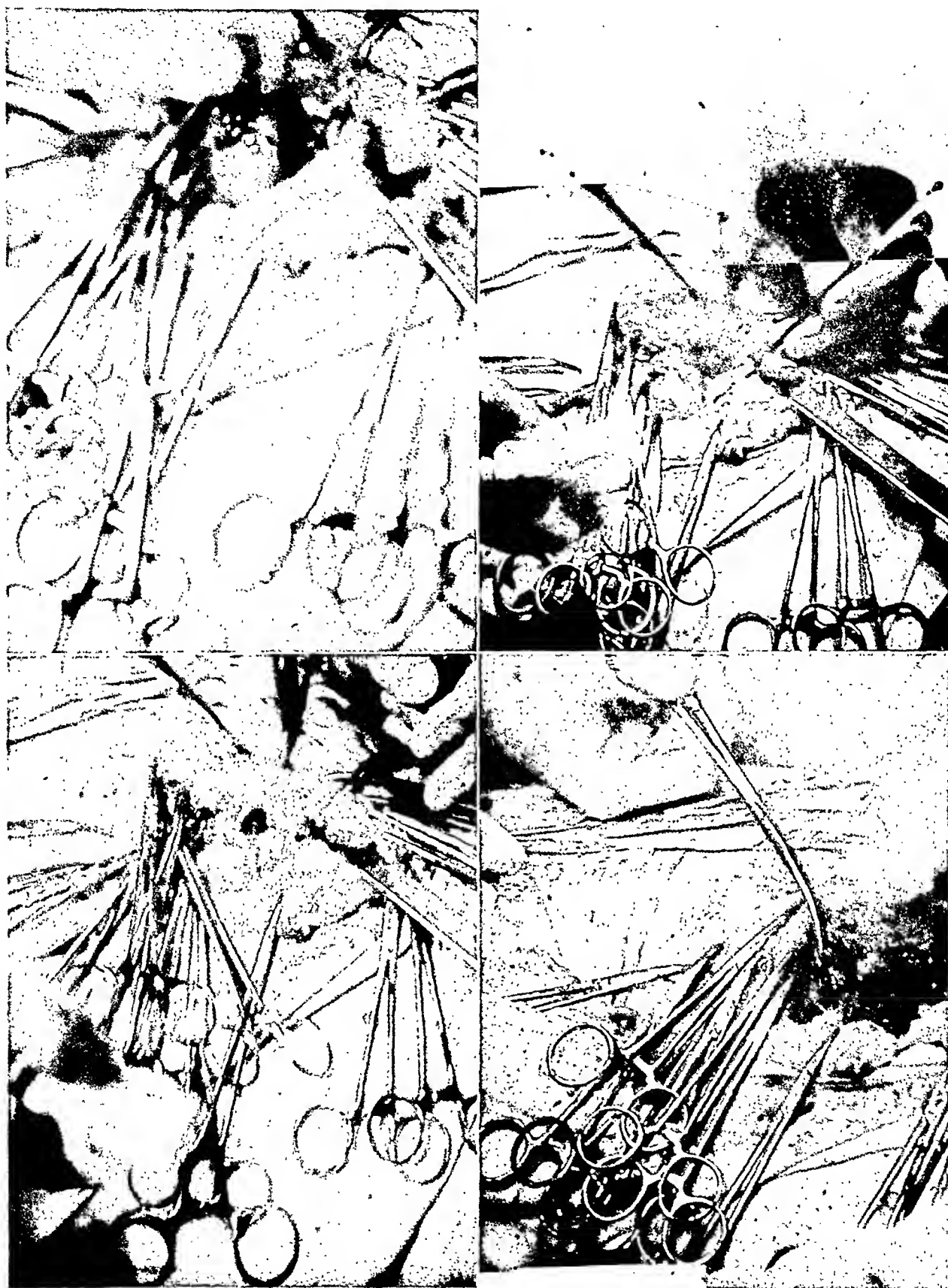


FIG. 5. Pencil has dropped out of hole in pericardium.

FIGS. 6, 7 and 8. Stages in opening pericardium to explore heart.

penetrated the chest wall and had reached or pierced the pericardium.

The patient was taken to the operating room where an exploratory pericardotomy was done under endotracheal, gas-oxygen-ether anesthesia through an 8 inch hockey stick incision, which was made along the left border of the sternum beginning at the third rib and extending downward and laterally. The skin incision was joined to the puncture wound caused by the pencil by an incision at right angles to it. The pectoralis major and minor were reflected upward and laterally, care being taken not to dislodge the pencil. Six inches of the fourth and fifth ribs were removed subperiostally, beginning at the sternal junction. The intercostal vessels were clamped, cut and ligated. The pleura was opened revealing the pencil still in place, having penetrated the pericardium and still pulsating with each heart beat. The pericardium was opened longitudinally. At this point the pencil fell out of the wound. The apex of the heart was grasped in the hand; no gross bleeding or penetration of the heart chambers was found. There was a small contusion of the heart muscle over the left ventricle 1 cm. lateral to the descending branch of the right coronary artery. About 2 ounces of blood found in the pericardium was removed. Reexamination of the contused area of heart muscle showed that the bleeding had stopped. The pericardium was closed with interrupted cotton sutures and the wound in the chest wall was closed in layers similarly. The patient remained in good condition during the operation. The pulse stayed below 95 beats per minute throughout. The blood pressure at the start of the operation was 100/66. During the operation the systolic pressure slowly and continuously climbed to 200, the diastolic remaining between 70 and 80. The blood pressure immediately postoperatively was 120/78.

He was given large amounts of penicillin (100,000 units every three hours) and 1 Gm. sulfadiazine every four hours postoperatively. An electrocardiogram taken the next day was interpreted by the medical consultants to show (1) sinus tachycardia; (2) left axis shift; (3) an elevated S-T wave with an upright QRS, "as is

found in pericardial effusion." The P-R interval was normal. A portable chest x-ray taken three days postoperatively showed cloudiness in the left base suggesting pleural effusion. The left lung was partially collapsed. A 6 foot plate taken one week later showed the pleural effusion at the left base still present. The pericardial shadow was reported slightly enlarged, with a cardiothoracic ratio of 15.5 cm. to 28.5 cm. A second 6 foot plate, taken on February 24th, showed pleural effusion still present at the left base with some beginning absorption. The cardiac shadow was globular in shape with a cardiothoracic ratio of approximately 16 cm. to 28.5 cm. Findings were considered consistent with pericardial effusion.

The patient made an uneventful recovery. His temperature and pulse were normal on the fifth postoperative day. The wound remained free from infection throughout. He was allowed out of bed on the seventeenth day after operation and returned home three days later.

An electrocardiogram taken six weeks after the operation was normal, as was an x-ray at this time, except for the missing resected ribs. The patient was allowed to return to school and has been leading a normal life except for athletic restrictions.

#### COMMENT

This boy exercised considerable intelligence in not allowing the pencil to be removed at the time of the accident.

When seen at the hospital, it could not be determined if the pencil had penetrated one of the chambers of the heart. For this reason, the operation was performed leaving the pencil *in situ* while removing chest wall structures around it. This was considered necessary until the pericardium had been opened and the exact damage assayed. Had massive bleeding been coincident to removal of the pencil, it could not have been controlled until the pericardium was widely open and the heart grasped.

Acknowledgment is made to Dr. John C. Van Dyne for the photographs appearing herein.



# INTUSSUSCEPTION IN ADULTS\*

## REPORT OF A CASE DUE TO ABERRANT PANCREAS

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UNLESS a physician has personally encountered a case of intussusception in an adult he is apt to think of it, if at all, as a very rare condition. Uncommon as it is, when compared either with the other lesions of the bowel for which most laparotomies are performed or with the incidence of intussusception in infants and children under fifteen years of age, it does occur with sufficient frequency to make its recognition and proper treatment a matter of concern to the general surgeon. Ten per cent of one series of 115 cases of intussusception have been reported as occurring in adults above the age of fifteen. Four of fifty-nine cases in a similar series were adults over twenty-one while nine out of twenty-seven in a third series were adults.<sup>1</sup>

At the New York Hospital during the eleven-year period, 1935 to 1945 inclusive, there were four proved cases of intussusception in adults and fifty-one cases of intussusception in children less than fifteen years of age among 180,266 admissions. The ratio of adults to children in this series was approximately 1 to 13.

It is safe to say, therefore, that about one out of every ten or twelve cases of intussusception occurs in an adult or late adolescence although other investigators have put the ratio as low as one out of every twenty or twenty-five.<sup>2,3</sup> Unfortunately, at the New York City Hospital, where the case to be presented was admitted, the ratio of adult to child intussusception can not be determined from the records.

Tumors frequently are present in intussusception. In a classical review, Eliot and Corscaden<sup>1</sup> found among some 300 cases collected and reviewed from the

literature. The presence of the tumor presumably was the cause of the invagination. Christopher,<sup>4</sup> in 1936, added fifty-nine more cases from the literature, in which the intussusception was due to tumor, and reported two cases of his own. The tumor mass usually lies at the apex leading the invaginated bowel along. In only two instances, quoted by Eliot and Corscaden, was the mass at the base. The majority of the tumors are benign. Pancreatic tissue forming the tumor, as was present in our case, has been reported only three times. Eliot and Corscaden mention a male child four years of age in whom "an accessory pancreas in the blind end of a diverticulum had formed a pedunculated tumor in the lower ileum." Christopher cited two other cases with accessory pancreatic tissue forming part of the intussusceptum.<sup>5,6</sup>

The clinical picture of intussusception in the adult frequently does not follow the classical pattern presented in infancy or childhood. The diagnosis in a very young person is fairly obvious for there is usually obstruction with vomiting, an elongated, moveable, palpable mass, which may change its size and position, and a bloody mucous discharge from the rectum. In the adult the course may be more insidious in onset and more prolonged in its duration. There may be constipation, diarrhea or normal bowel function at times; blood and mucus are frequently lacking; a mass may not be palpable owing to a thick fatty abdominal wall or, as in the case to be presented, well developed musculature; and the history of pain may be very misleading and simulate that of cholelithiasis, peptic ulcer or ureteral calculus.

In the acutely obstructed adult the only

\* From the surgical service of Dr. Preston A. Wade, New York City Hospital.

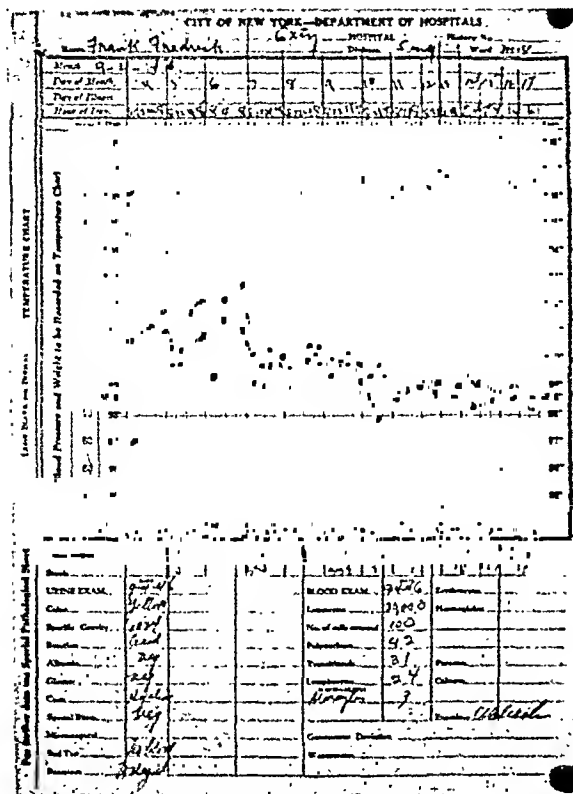


FIG. 1. Chart showing clinical course.

effective treatment is surgical. If the intussusception can be reduced readily under direct vision, this should be done but vigorous and prolonged attempts should not be made. If the intussusception is due to a tumor or Meckel's diverticulum, the latter should be removed even though this involves resection of a loop of bowel; otherwise the condition is bound to recur. When the intussusception is irreducible no time should be lost in performing a resection well away from the limits of the involved segment. Immediate primary anastomosis is then advisable when the lesion is confined to the small bowel. Rarely should it be necessary, because of the patient's poor general condition, to exteriorize the involved loop or its resected ends. The latter procedure complicates the picture tremendously due to the drainage of small intestinal contents and the necessity of a subsequent operation. In lesions of the large bowel which can be mobilized, ex-



FIG. 2. Photograph of resected intestine opened to show the mucosal surface. The large arrow points to the tumor mass at the upper pole of the intussuscepted loop which has been partially released to demonstrate the site of tumor more clearly. The small arrow points to the region (the small light area) through which the ducts emptied into the lumen of the intestine.





FIG. 3. A, low power view of the tumor showing the preserved intestinal mucosal covering and the dense hyaline tissue enclosing the pancreatic acini and ducts. B, higher power view which shows the acinar and duct structures.

teriorization and resection by either the Paul—Mikulicz or the Rankin obstructive technic may be preferred as offering additional safety although it requires two stages.

#### CASE REPORT

F. F., a twenty-nine year old male elevator operator, was admitted to the New York City Hospital at 8:00 A.M. on September 4, 1946, with the chief complaint of severe abdominal pain. He had returned from work at 11:30 P.M. the preceding night and, about one hour after having consumed some bread and soup with four glasses of beer, he experienced severe pain in the upper abdomen. The pain was associated with nausea and he vomited a considerable amount of greenish material. The pain became progressively worse and gradually localized in the mid-upper abdomen. The past history was significant in that he had always had a poor appetite and for a year or more had had occasional attacks of "indigestion" lasting half an hour to an hour after meals which was relieved by taking "alkaloids." The present attack was similar to others but more severe. There was no history of constipation, diarrhea, bloody or tarry stools, preprandial pain, jaundice or aversion to fatty foods. He was a recently discharged veteran and had been stationed in Panama where an appendectomy had been performed in 1936. It was noted in his family history that his father died of pulmonary tuberculosis.

The patient was a well developed and nourished young white male in acute distress, restless, perspiring and moving about in bed in an attempt to relieve his pain. He kept his legs flexed on the abdomen. His temperature was 97°F., pulse 98; respiration 22; blood pressure 165/90. Physical examination was negative save for the abdomen which was moderately distended with marked involuntary spasm in the mid-epigastrium and periumbilical regions. The liver, spleen and kidneys could not be felt nor were any masses palpable although examination was rather unsatisfactory due to a thick muscular wall and the presence of spasm. The abdomen was slightly tympanitic to percussion and there was audible peristalsis on auscultation. Rectal examination revealed acute tenderness high up but no blood was noted on the examining finger and no masses could be felt.

The urine was negative except for an occasional hyaline cast. A blood count showed: hemoglobin 97; red blood cells 4,700,000; white blood cells 20,000; polymorphonuclears 42; transitionals 31; lymphocytes 24; monocytes 3. An x-ray of the abdomen with the patient erect failed to reveal any free air beneath the diaphragm.

A presumptive diagnosis of perforated peptic ulcer was made and at 10:30 A.M. on September 4, 1946, ten hours after the onset of his symptoms, an exploratory laparotomy was performed under spinal anesthesia through a right rectus muscle splitting incision.

There was a slight amount of clear free fluid in the peritoneal cavity. The stomach, duodenum and gallbladder were normal. About 15 cm. proximal to the ileocecal junction a large mass was encountered which proved to be an ileoileal intussusception. This mass measured 30 cm. overall in length and 6 cm. in diameter. It was bluish red, tense and firm. Loops of bowel proximal to the intussusception were moderately distended while those distal to it were collapsed. The vessels in the adjacent mesentery were thrombosed and no pulsations could be felt in them. As all reasonable efforts to reduce the intussusception were unsuccessful, an immediate resection was done about 6 cm. from either end of the intussuscepted mass. The intervening mesentery also was removed. A primary open end-to-end anastomosis was then effected and the abdomen was closed in layers with silk, without drainage.

Following operation, a Miller Abbott tube was passed and the patient was maintained on intravenous fluids until the third day when oral feedings were started. He was on a full normal diet by the sixth day at which time he was allowed out of bed. The temperature and pulse record is reproduced in Figure 1. At no time was he distended, his recovery was remarkably smooth, the wound healed *per primam* and he was discharged from the hospital September 19, 1946, fifteen days after admission and operation.

Report of the pathologist (Dr. James R. Lisa) is as follows: The section of small intestine (Fig. 2.) measures 35 cm. in length and the serosa is smooth. The distal 29 cm. is dilated to a circumference of 8 cm., the proximal portion is only slightly less. At the junction there is a thickened white serosal portion. On opening the lower part an intussuscepted loop is displayed extending its entire length, deeply injected, 5 cm. of the tip being cyanotic. The upper loop on opening appears normal down to the point of origin of the intussusception where there is a marked constriction, corresponding to the thickened serosal area. On releasing the invaginated loop a rounded tumor mass is found at this point

3 cm. in height and 2.5 cm. through the base, covered with preserved mucosa. At the tip is a small pointing circular area, apparently ulcerated. On section, the mass is solid, firm and white with a central nodular hard mass. At the tip is a small cyst. There is no evidence of a Meckel's diverticulum.

Microscopically, the tumorous mass consists of normal acinar pancreatic tissue with its ducts lying in a densely hyaline connective tissue sealing the outer muscular coats. (Fig. 3A.) Toward the tip the muscle coats are lost, the ducts become dilated; the cystic area, being a greatly dilated duct, is visible with the naked eye. The surface is covered with normal intestinal mucosa through which the pancreatic ducts empty into the lumen at the point which presented as the pointing area and is grossly visible. Islet tissue is absent. (Fig. 3B.) Other portions of the loop show only those changes due to the strangulation of intussusception.

Diagnosis: Intussusception of ileum due to tumorous, aberrant, pancreatic tissue.

#### SUMMARY

A case of intussusception in an adult caused by a solid tumor of aberrant pancreatic tissue is presented. The clinical picture and treatment of intussusception is considered and the literature on the subject briefly reviewed.

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# PSEUDOCYST OF THE PANCREAS\*

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A REVIEW of the literature by Harrison and Cooper<sup>1</sup> in 1943 reveals fifty-two cases of pseudocysts of the pancreas of traumatic origin. Since then the literature includes one other case reported by Pascucci,<sup>2</sup> and we are reporting still another. A few reports which have not been included have recently occurred in some foreign journals.

*Incidence.* Many cysts of the pancreas occur as a result of infection and necrosis but there is a lesser number that occur as a result of traumatic injury. Jones<sup>3</sup> states that 20 per cent of all cysts of the pancreas are traumatic in origin. Mahorner and Mattson<sup>4</sup> report that twenty-eight of 119 gave a history of trauma. Judd,<sup>5</sup> in a series of forty-seven cases, reports an incidence of 15.7 per cent and he also states that at the Mayo Clinic from 1921 to 1931, there were 700,000 admissions of which eighty-eight patients were treated surgically for pancreatic cysts and that the incidence of those being traumatic in origin was 17 per cent. Heiberg<sup>6</sup> says that one-third of all cases of cysts of the pancreas are traumatic in origin. Korte<sup>7</sup> believes that one-fourth of cysts of the pancreas follow injury to the upper abdomen. He reported on 117 patients in whom thirty-three gave a history of injury. Rabinovitch and Pines<sup>8</sup> report eleven cases of pseudocysts of the pancreas, none of which were traumatic in origin. Adam and Nishijima<sup>12</sup> report that there were only nine pancreatic cysts encountered at the Lahey Clinic from 1926 to October, 1945. A history of trauma was elicited in only one patient.

*Etiology.* According to Harrison's<sup>1</sup> explanation, these traumatic cysts of the pancreas arise following a crushing blow to the upper abdomen with compression of

the pancreas against the lumbar vertebrae. This trauma causes a rupture of the pancreas with escape of secretion or inflammatory exudate into the lesser sac and then with the sealing of the Foramen of Winslow a cyst develops. Therefore, the cyst is not in the substance of the pancreas but in the immediate neighborhood, that is, in the lesser sac. There is no epithelial lining.

Drennen<sup>9</sup> states, "In the case where a cyst arises subsequent to the pancreatic injury, the following conditions probably obtain:

"The pancreas is torn or mashed in such fashion that some of the ducts are divided, with escape of pancreatic juice. Hemorrhage, of lesser or greater degree, occurs at the same time. If the peritoneal coat over the pancreas is torn, as is usually the case, then there will be fat necrosis involving the omentum. An adhesive peritonitis follows, sealing in the injured spot or spots of the gland.

"The pancreatic fluid continues to form, pushing its way between the peritoneal layers. Thus the cyst grows drop by drop, the endothelial lining of the wall contributing its share of fluid to dilute the pancreatic secretion. The color of the fluid varies as to the amount of blood contained.

"After a time when the intra-cyst tension has become very great, the torn ducts become sealed-off by contracting scar tissue, and at the same time the corresponding parenchyma cease to function and atrophy. The endothelium of the cyst wall may continue to secrete its fluid long afterward, the cyst thus grows larger and larger."

*Contents of the Cysts.* Harrison<sup>1</sup> lists the contents of these cysts as varying amounts of blood, pancreatic secretion, inflamma-

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tory exudate and necrotic fluid. A cyst containing all of the three pancreatic ferments is only suggestive of its being pancreatic in origin because any cyst containing blood will have these ferments in it. However, if the cyst contains a great deal of trypsin, it is right to suppose that it is of pancreatic origin. Amylopsin is obtained from other fluids in the body as is steapsin. The absence of pancreatic ferments does not rule out a pancreatic cyst because ferments may be absent in old cysts.

*Symptoms and Physical Findings.* Harrison<sup>1</sup> in his discussion says that at the time of the accident there is extreme pain accompanied by nausea, vomiting, weakness and shock. Occasionally, the symptoms are mild but, because of their severity, most patients are sent to the hospital for a few days observation. Following the injury, the examination reveals tenderness in the epigastrium with muscle spasm in that area. These usually subside in a few days. When the cyst develops, the accompanying symptoms are those related to mechanical interference with the function of the surrounding organs. Upper abdominal fullness with gaseous distention occur with a loss of appetite, nausea and vomiting. This is usually followed by cramping or aching epigastric discomfort. Weakness, loss of weight and general debility manifest themselves as the condition progresses. About this time, the patient feels the mass between the xiphoid cartilage and the umbilicus. The mass is located in the lesser peritoneal sac, and is globular, smooth and usually slightly movable but not displaceable. It may or may not be tender. Sometimes there is a systemic reaction with elevation of temperature and a leukocytosis.

*X-ray Findings.* Because traumatic cysts of the pancreas are an effusion into the lesser peritoneal sac, Morrison's<sup>10</sup> list of roentgen signs may be of value in determining this condition. He states that a direct shadow of the effusion will be present if the collection of fluid is large. There will be a defect in the air or barium-filled stomach, probably on the lesser

curvature and posterior wall in small effusions, downward displacement of the stomach to the left and posteriorly if the effusion is large. Kidney outlines will be preserved. There will be an increased pliability and compressibility of the gastric walls on fluoroscopic palpation. Chest findings are those of other subdiaphragmatic lesions, namely, elevation of diaphragmatic leaf with possible decreased respiratory excursion on the left.

Holt<sup>11</sup> states that a complete examination of the gastrointestinal tract is indicated if a cyst of the pancreas is suspected. If the cyst arises from the head of the pancreas, the duodenal loop will be widened with little or no deformity of the stomach. A cyst arising from the body of the pancreas displaces the stomach anteriorly and superiorly with variable distortion of the small bowel. If the cyst arises from the tail of the pancreas, there will be a deformity of the greater curvature of the stomach at or just above the mid-portion with anterior displacement. The splenic flexure of the colon may either be indented or displaced caudally.

*Treatment.* According to Harrison,<sup>1</sup> diagnostic aspiration is contraindicated because of the danger of going through the stomach, colon or small bowel. Operation with complete extirpation of the cyst wall, if possible, is the treatment of choice. This is not always possible because of its intimate relation to the surrounding structures. If the latter is the case, marsupialization must be resorted to and drainage instituted. Anastomosing the cyst with the intestinal tract, usually the jejunum, has been advocated for other types of pancreatic cyst but it is seldom necessary to do so in those having traumatic origin.

*Results.* Operation usually results in a permanent cure. In those patients in whom the cyst wall can be removed the results are very good. If one has to resort to marsupialization, then drainage for a protracted period can be expected but end results are usually good because once the tract closes there is seldom further trouble.

## CASE REPORT

On August 29, 1945, K. C., a white male aged five years, entered Mercy Hospital, Council Bluffs, Ia., on the service of the Cogley Clinic with the history of having fallen from a bicycle fourteen days previously. He had just finished his evening meal and went for a ride on his bicycle when he hit a rut and lost control. Immediately after the accident, he walked about 40 feet in a stooped position holding his stomach before he fell exhausted and dyspneic. He was carried to the house and put to bed. An hour later he became nauseated and was taken to the doctor who examined him and sent him home. On the way he vomited twice and four times more during that night. The next day he vomited nearly every hour but stopped after hot packs were applied to the abdomen. During the next few days he ran an intermittent fever and became listless, pale and suffered anorexia. His white blood count began to rise and the pain in his abdomen continued so he was sent to the hospital after fourteen days of observation at home.

The physical findings revealed a thin, poorly nourished child with a temperature of 101.6°F. and tenderness in the upper abdomen. In the epigastrium, the circular impression of the handle bar, which did not have a grip, was plainly visible.

The laboratory findings disclosed that the red blood count was 3,100,000 with a hemoglobin of 68 per cent. The white count was 13,300 with 76 per cent polymorphonuclear leukocytes and 4 per cent stabs; there were 20 per cent lymphocytes. The urine was acid with a specific gravity of 1.030, the albumin was negative as was the test for sugar. The microscopic examination was negative while the sedimentation rate at the end of an hour was 29 mm.

The x-ray findings were reported as follows: "Film of chest shows no definite pathology. There appears to be a homogenous shadow in upper abdomen, may be a hematoma."

The preoperative diagnosis was a hematoma in the upper abdomen, possible hemorrhage from the spleen.

The patient was operated upon on the nineteenth day following injury under a general anesthetic. A high, left rectus incision was made and the mass in the upper left quadrant explored. The lesser sac was distended with a thin turbid fluid. The cyst was aspirated and its wall excised. The peritoneum was closed with No. 0 chromic. The fascia was closed with continuous and interrupted No. 0 chromic. Clips were used to approximate the skin edges. The patient received 500 cc. of whole blood during the operation.

The report of the fluid from the cyst revealed that the amylase content of the fluid was equivalent to 400 mg. of sugar, concomitant with that of pancreatic origin.

During the postoperative course the patient's temperature remained elevated for four days and then returned to normal. The patient steadily improved and he was dismissed on the fourteenth postoperative day entirely relieved of symptoms. The patient was well one year later with no symptoms or evidence of recurrence.

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# DEMONSTRATION AT OPERATION OF SPHINCTERIC ACTION AT THE TRUE GASTRIC STOMA\*

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THERE has been considerable controversy in the literature as to whether or not a sphincter forms at the site of the gastric stoma following subtotal gastrectomy. The controversy becomes further complicated by the lack of a clear understanding as to just what the gastric stoma is following gastrojejunostomy. Most European surgeons<sup>1</sup> consider the circumference of the anastomosis as being the gastric stoma. This opinion is also shared by many surgeons in this country with whom we have discussed this problem. American literature is singularly lacking in any reports about the question of the gastric stoma. For this reason, in another publication<sup>2</sup> we endeavored to call attention to the fact that the "true gastric stoma" is not the circumference of the stomach outlet in the anastomosis but is only the circumference of the jejunum at the lower end of the anastomosis.

Vitkin<sup>3</sup> denies the existence of a sphincter following gastrojejunostomy as do many other European writers. Some, such as Wölfler, have shown what is considered to be a sphincter at the site of the anastomosis as a result of a Billroth 1. Other surgeons state that by plication of the intestinal circular fibers at the site of the anastomosis such a sphincter could be formed but would not be a true sphincter. On the whole, the consensus of opinion among surgeons everywhere is that no true sphincter is formed following subtotal gastrectomy, and that any demonstration of submucosal thickening is merely due to the plication of the layers at the site of the anastomosis.

Raydin, Johnston et al.,<sup>4</sup> in a series of experimental studies, have shown that

some peristaltic activity occurs at the upper end of the jejunum at the site of the anastomosis when different types of food are ingested. They consider this peristaltic activity to be caused by the normal peristalsis of the intestine due to stimulation of its mucosa by the irritative effect of certain foods or due to the normal physiologic response of the small bowel to the introduction of a bolus of food. They do not believe in the existence of a sphincter.

In our case report, not only was there a perfect demonstration that the "true gastric stoma" is that circumference of the jejunum at the site of the anastomosis (lower end), but definite sphincteric action was noted at this "true gastric stoma." Examination of Figure 1 demonstrates the appearance of the stomach at operation. The lower gastric wall (jejunum) was seen to bulge downward producing a relative displacement of the gastric stoma to the left. Note that there is a definite constriction at the "true gastric stoma" as shown in this figure. At operation this constriction was seen to relax and then constrict again much like the pylorus. Examination of Figures 2 and 3 show different phases of contraction and relaxation at the true gastric stoma. Only one narrow ring like a sphincter appeared to take part in this peristaltic activity.

## CASE REPORT

A. P., a thirty-six year old colored man, was admitted to Grace Hospital for the surgical repair of an incisional hernia. He had been operated upon four years previously at which time a subtotal gastrectomy was done. This was an anterior gastrojejunostomy of the Polya type. Following this operation, the patient developed an incisional hernia.

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On examination, the patient was found to be a well nourished colored man. He lay comfortably in bed and did not appear acutely ill. An aeneiform eruption was quite evident over his shoulders and back. His temperature was 98.6°F., pulse 80, respirations 20. Examination of his head, eyes, nose and throat were entirely normal. The lungs were resonant to percussion; voice and breath sounds were normal; tactile fremitus was normal and there were no râles. The heart was not enlarged to percussion. A soft, systolic, apical murmur was noted. Pulses were equal and regular and there was no pulse deficit. Heart rate was regular; blood pressure was 130/80. His abdomen was flat. There was a large mid-abdominal incisional hernia at the site of the previous operative scar. The recti muscles were widely separated. No tenderness was noted over the mass. The liver edge was not palpable. No masses were found other than the hernia and no spasm was present. The genitalia were normal and the extremities showed no pitting edema. Reflexes were also normal.

On January 11, 1946, under continuous spinal anesthesia a spindle-shaped incision was made about the old mid-line scar and the scar ex-

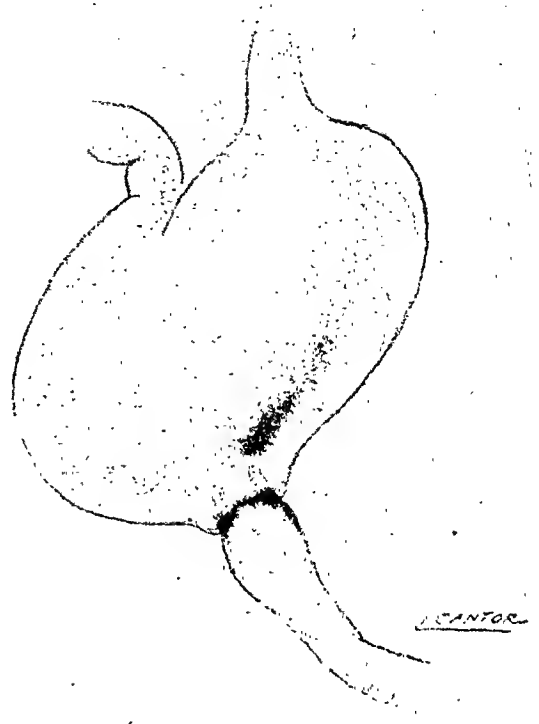


FIG. 1. Note the out-pouching of the lower gastric wall (jejunum). The "true gastric stoma" is now displaced to the left. The definite constriction is at the point of the true gastric stoma with the dilated jejunum beneath. Sphincteric action was noted clinically at this point of constriction.



FIG. 2. The constriction of the column of barium as it passes through the true gastric stoma. The proximal loop which is non-functional does not visualize. Note the down-pouching of the lower gastric wall (jejunum).



FIG. 3. This film shows the relaxation at the true gastric stoma permitting a free flow of the barium into the jejunum.



cised. On entering the peritoneal cavity, it was found that the jejunum was attached to the scar in several places and a perforation of the jejunum was avoided with much difficulty. A sac, about half the size of one's head, finally was freed from the layers of the abdominal wall. It was observed that at the site of the old gastric resection the jejunum was pouched downward so that it had a diameter of 2 or 3 inches, and at the lower angle of the Polya attachment of the jejunum to the stomach there was a definite constriction of the jejunum with a sphincter-like action. Under observation on the operating table, this portion of the jejunum would contract to one-half or one-third the diameter of the remaining jejunum and would then relax. It exhibited true sphincteric activity. The abdominal wall was closed by the Mayo method for ventral hernia repair. The inner two rows of sutures imbricated the abdominal wall from left to right, and an outer row of interrupted wire was added. The skin incision was closed with interrupted nylon and running catgut.

The patient developed lobar pneumonia on the fifth postoperative day but response to penicillin therapy was prompt and he made an uneventful recovery. He was discharged as cured on the thirteenth postoperative day.

#### SUMMARY

The case herein reported is quite uncommon in that it is rarely possible for the surgeon to have an opportunity to survey the site of the anastomosis while the patient is alive. The observations made at this operation clinically (by direct vision) prove two points: First, if Figure 1 is noted, it becomes quite evident that the stomach enlarged to accommodate normal meals postoperatively following subtotal gastric resection by the out-pouching of the jejunal wall, and second, a circular bundle of muscle fibers at the true gastric stoma became hypertrophic and by rhythmic contraction and relaxation showed all

the characteristics of a true sphincter. Many surgeons have discussed the absence or presence of a hypothetical sphincter but never before, as far as we know, has it been possible actually to demonstrate its existence. We are at present engaged in experimental work to prove by means of microscopic sections whether such a sphincter usually forms. Figures 2 and 3 show roentgenograms taken of this patient. Note the contraction and relaxation as shown on the barium column passing through the true gastric stoma. Note also the downpouching of the lower gastric wall (jejunum).

#### CONCLUSION

A case of a man whose abdomen was opened to repair an incisional hernia is reported with the following observations: (1) A definite enlargement of the stomach by the mechanism of outpouching from the jejunal wall is noted. (2) A definite sphincter contracting and relaxing at the "true gastric stoma" was noted. (3) The "true gastric stoma" is the circumference of the jejunum at the lower end of the anastomosis and is not the entire circumference of the anastomosis.

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# NON-TRAUMATIC PERFORATION OF THE COMMON BILE DUCT

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**S**PONTANEOUS rupture of the common bile duct without antecedent history of trauma or surgery to the duct appears to be an exceedingly rare complication of gallbladder disease. A careful review of the literature reveals but five references to spontaneous rupture unassociated with trauma or surgery. We believe our case warrants reporting because of the rarity of the condition.

## CASE REPORT

H. K., a white male, age twenty-five, complained of crampy pain in the epigastrium of three weeks' duration, occurring one hour after meals and lasting one to two hours. This pain was relieved at first by taking bicarbonate of soda but one week prior to hospitalization the pain changed in character and became constant and intractable. At this time the patient's complaints consisted of malaise, weakness, headache and several bouts of afternoon chills and fever. The family physician interpreted these findings as consistent with "flu" and after five days of bedrest and symptomatic therapy the patient felt much improved and resumed his daily routine. Two days later the malaise, fever and chills, accompanied by severe non-radiating epigastric pain returned and jaundice was noted. The patient was admitted to the hospital.

His past history disclosed that the patient had experienced a similar episode of pain one year prior to his present illness which was relieved by soda bicarbonate but was unaffected by amphojel. There was no history of trauma save for a war injury of the left kidney sustained in 1944 which necessitated a left nephrectomy in 1946 because of persistent hematuria.

Physical examination revealed a lean, well developed male who appeared acutely ill and in obvious distress. His temperature was 100.2°F., pulse 98, respirations 20. The sclerae and skin were moderately icteric. There was

tenderness and some rigidity in the right upper quadrant with subxyphoid tenderness. The liver, spleen, kidney and gallbladder were not palpable. The remainder of the examination was non-contributory.

Laboratory studies on admission showed urine with a trace of albumen, positive for the presence of bile but negative for the presence of urobilinogen; hemoglobin 85 per cent; red blood cells 4.45 million; white blood cells 12,000 with a normal hemogram. Serum amylase and blood chemistry studies were all within normal limits; icterus index, 64.

The patient was admitted to the medical service and the differential diagnosis considered was: (1) Penetrating duodenal ulcer into the liver with secondary hepatitis; (2) infectious hepatitis with an intrahepatic obstructive phase.

Penicillin therapy (40,000 units every three hours) was instituted immediately but despite it the patient's temperature rose to 104°F. on the day following admission. Gastrointestinal x-rays on the second hospital day were negative for ulcer. The jaundice increased and the icterus index rose to 73. The stools became acholic in appearance and were negative for hydrobilirubin. The urine was negative for urobilinogen on repeated examinations. On the second and fifth hospital days the patient had a severe chill despite penicillin therapy followed by a temperature rise to 103°F. On the morning of the sixth hospital day the patient's pain became more severe, the abdomen became more rigid especially in the right upper quadrant and surgical consultation was requested. A urinalysis revealed urobilinogen strongly positive in the urine for the first time. Because of the severe pain, abdominal spasm, pattern of chills and fever, increasing icterus and leukocytosis, a preoperative diagnosis of septic cholangitis was made.

At operation under continuous spinal anesthesia an upper, split, right rectus incision was made. The liver was considerably enlarged. Inspection revealed the gallbladder to be



Fig. 1. The area of perforation of the bile duct and the gallbladder, seen through the cystoscope. An arrow points to the site of perforation of the gallbladder.

infection of the biliary tract, and the patient was treated with antibiotics and analgesics. The patient was discharged on the eighth day of hospitalization. The patient was readmitted to the hospital on the twelfth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the fourteenth day of hospitalization. The patient was readmitted to the hospital on the twentieth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the twenty-second day of hospitalization. The patient was readmitted to the hospital on the twenty-eighth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the thirtieth day of hospitalization.

The patient was readmitted to the hospital on the thirtieth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the thirty-second day of hospitalization. The patient was readmitted to the hospital on the thirty-eighth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the fortieth day of hospitalization.

perforation was inserted. It was believed that the patient was in the early stages of peritonitis, and the patient was treated with antibiotics and analgesics. The patient was discharged on the fourth day of hospitalization. The patient was readmitted to the hospital on the tenth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the twelfth day of hospitalization.

The patient was readmitted to the hospital on the twelfth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the fourteenth day of hospitalization. The patient was readmitted to the hospital on the twentieth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the twenty-second day of hospitalization.

The patient was readmitted to the hospital on the twenty-second day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the twenty-fourth day of hospitalization. The patient was readmitted to the hospital on the thirtieth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the thirty-second day of hospitalization.

The patient was readmitted to the hospital on the thirty-second day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the thirty-fourth day of hospitalization. The patient was readmitted to the hospital on the fortieth day of hospitalization, because of persistent abdominal pain and fever. The patient was treated with antibiotics and analgesics. The patient was discharged on the forty-second day of hospitalization.

in the presence of inflammation are exceedingly rare. The majority of reported perforations of the duct system in the literature are found associated with trauma or previous surgery. As early as 1912, McWilliams reviewed ninety cases of perforations occurring in the extrahepatic biliary system from all causes and found that 91 per cent occurred in the gallbladder, 4.4 per cent in the common duct, 3.3 per cent in the cystic duct and 1.1 per cent in the hepatic duct. Woodruff A. Smith collected eleven cases and reported one of his own of intrahepatic bile duct rupture with escape of bile from the surface of the liver.

Bailey, Vale and Shapiro, and Newel have each reported a case of spontaneous rupture of the choledochus in which there had been no associated trauma, surgery or impacted stone. Reich has reported the same for the hepatic duct. Newel found no obstruction at any point in the common duct or hepatic ducts to account for rupture. He has explained the perforation on a basis of an acute choledochitis combined with spasm of the sphincter of Oddi resulting in temporary partial obstruction which in turn produced an empyema of the duct and rupture at the weakest point. He has also mentioned Burden's etiologic doctrine and invites the possibility of a small stone arising in the glands and imbedded in the wall of the inflamed duct producing rupture.

The etiologic explanations for common duct rupture may be many. The factors which we believe are called most frequently into play are listed below:

1. *Common duct stones may become impacted* in the duct and produce a pressure necrosis of the wall which, when combined with an inflammatory process, may produce rupture. Walters has pointed out that the epithelial lining of the duct is remarkably resistant to trauma which accounts, perhaps, for the relative infrequency of spontaneous rupture.

Burden has pointed out that the biliary ducts contain numerous glands in their walls, extending almost to the peritoneal

coat. Normally, these sacculi contain no bile but contain the mucous secretion of these glands. In a dilated, diseased duct these glands may be the seat of infection and calculus formation may occur. Under unusual circumstances, i.e., cholangitis with increased intraductal pressure, perforation may result.

2. *Infection and Increased Intraductal Pressure.* Newel's explanation has already been cited, namely, that with acute cholangitis and spasm of the sphincter the temporary, partial obstruction may be sufficient to produce empyema of the duct with perforation at the weakest point. Frequently these cases demonstrate a predilection for the site of old choledochostomies as the site of rupture. Wolfson and Levine have reported three cases of spontaneous rupture of the duct following choledochostomy. Newburger has reported nine such cases.

The intraductal pressure increases may be due to spasm, stone or frequently both. Thus the duct distends and rupture occurs at the critical point of distention.

3. *Arterial thrombosis* might account for cases in which the rupture occurs independent of the site of former manipulation and instrumentation.

4. *Direct and indirect trauma* may produce rupture of diseased or even normal bile ducts.

5. *Choledochus cysts*, though rare, may produce spontaneous rupture. In Taube's case a lemon-sized cystic mass seeping bile was found located at the retroduodenal portion of the choledochus.

6. *Diverticula* of the choledochus may be listed as a rare pathologic entity. However, one of us (H. M. G.) has recently operated upon a patient with jaundice whose common duct contained eleven diverticula in each of which a mixed stone was impacted. It seems quite possible that under conditions of increased intraductal pressure and in the presence of inflammation, one or more of these stones may erode a diverticulum and produce a perforation.

## COMMENT AND SUMMARY

A case of spontaneous perforation of the common duct associated with stone has been presented. A brief review of the literature and a description of the factors which may lead to such a perforation have followed.

In retrospect, albeit hypothesis, it would appear that during this patient's first attack of pain one year prior to his present illness, a small cholesterol stone was pushed from the gallbladder into the common duct. It remained there as a silent stone until the recent chain of symptoms began. At this time in the presence of septic cholangitis it eroded through the duct wall and after perforation produced the sudden severe pain and chemical peritonitis. With the partial extrusion of the stone from the duct, bile was once again able to gain entrance into the intestinal tract and undergo reduction to urobilinogen which appeared in the urine for the first time on the operative day.

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# CONGENITAL MEGACOLON-HIRSCHSPRUNG'S DISEASE

## MEGACOLON TREATED BY SEGMENTAL RESECTION

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**H**IRSCHSPRUNG'S disease or megacolon was established as a clinical entity in 1888 as "a condition of congenital, high grade dilatation of the colon with thickening of all its tunics, especially the tunica muscularis and retention of large quantities of fecal matter." The acquired type of megacolon although pathologically identical with its congenital relative differs etiologically from the entity described by Hirschsprung.

Any mechanical obstruction of the large bowel is followed by hypertrophy and dilatation above the obstruction, thus considering the early age of appearance of symptoms of the disease it is possible that some embryonal defect is present which cannot be demonstrated at either operation or necropsy.

The fact that the sigmoid is the most common site of the lesion and is usually found enormously enlarged the possibility of redundancy with chronic volvulus due to either kinking, angulation or adhesions must be considered in the etiology of this condition.

Rankin believes that the pathogenesis is mixed, that there are often several etiologic factors as an embryonal defect situated either in the motor mechanism of the bowel itself or may be explained by ectasis of the wall of the bowel, or there is a mechanical, congenital defect which, although not demonstrably obstructive, produces the three cardinal anatomic features of megacolon, namely, dilatation, elongation and hypertrophy. Attempts to demonstrate mechanical obstruction in the congenital cases have failed as have any demonstration of faulty mechanism of resected nerve specimens.

Megacolon is more common in male infants, the incidence being 3:1; approximately a fourth of the cases are seen before the age of five years.

Although the sigmoid is the most usual site of involvement, the process tends to extend proximally so that the descending transverse and ascending colon and finally the cecum may be implicated. In rare cases the lower part of the ileum is involved resulting in a condition of megaileum. Although the lesion usually ends at the junction of the sigmoid and rectum, the rectum is sometimes involved to a minor degree. The dilatation may become enormous so that the pelvic colon resembling a flexed leg and thigh may come to occupy the entire abdomen and cause extreme distention with obliteration of liver dullness and marked umbilical protrusion.

With surgical attack on the colon constituting a dangerous hazard associated with a prohibitive mortality prior to present day adjuvants to colon surgery in the form of sulfasuxidine and penicillin, the treatment was directed toward the etiological factor of neuromuscular obstruction. This condition was placed in the same category as cardiospasm, spasmodic obstruction of the pharynx and other examples of so-called achalasia, a term indicating that the essential defect is an inability of the sphincter to relax rather than a true spasm. The colon and rectum are innervated by a double nerve supply from the autonomic nervous system. The circular muscle fibers are supplied from the lumbar rami communicantes passing down through the sympathetic trunks and the hypogastric and pelvic plexuses. The longitudinal fibers on the other hand are

supplied by the parasympathetics. Hyperactivity of the sympathetic innervation to the pelvirectal junction leads to a condition of increased tone of the sphincter. Thus Wade and Royle, in 1927, were the first to suggest sympathectomy for the treatment of idiopathic megacolon. In 1930, Rankin and Learmonth modified the technic of the operation in which a transperitoneal division of the presacral and inferior mesenteric nerves is accomplished.

Grimson, quoting Finney, Eiss and deTakats and Biggs has summarized the mortality rate associated with the medical management of megacolon as averaging 58 per cent. Although the patients can be controlled for long periods of time, the bowel may perforate during an impaction episode leading to peritonitis and death.

Of all the surgical procedures resection of the involved bowel was the most satisfactory, but prior to the advent of sulfasuxidine in the preoperative preparation of the patient the high mortality associated with resection prevented its uniform acceptance.

Poth has demonstrated that sulfasuxidine and sulfathalidine alter and simplify the bacterial flora of the gastrointestinal tract. His first report in 1942 on a series of fifty patients receiving sulfasuxidine both pre- and postoperatively revealed the absence of fecal fistulas and peritonitis and no deaths in the series. After four years evidence has accumulated that sulfasuxidine and sulfathalidine when given in adequate dosage will produce a significant modification of the bacterial flora of the bowel and give a satisfactory mechanical preparation of the bowel preceding surgical operations while the patient is maintained on an adequate protein and carbohydrate diet. Postoperative morbidity studies indicate that these drugs when properly used in the preoperative and postoperative surgical periods will contribute to the lowering of the operative mortality and make an occasional procedure possible which might otherwise not be feasible.

Moses Behrend using sulfasuxidine 0.5 Gm. to a Kg. of body weight for one week has successfully carried out open end-to-end anastomosis of the colon.

Karl A. Meyer et al. used the open anastomosis on a series of twenty patients administering sulfasuxidine for a period of from seven to fourteen days before surgery in doses varying from 12 to 18 Gm. per day. There was one death in this series due to pulmonary embolism, a mortality of 5 per cent.

Waugh and Custer in a series of fifty cases using a primary aseptic anastomosis resorted to 10 Gm. of sulfasuxidine daily for four days prior to operation. Their mortality rate for the entire series was 4 per cent.

Poth and Knotts state that the sulfasuxidine given in therapeutic doses alter the feces because they become semifluid and practically odorless. Thus as a result of preparation of the patient with sulfasuxidine, parenteral feeding and a non-residue diet the colon is practically empty at the time of operation and thus proximal colostomy or cecostomy is unnecessary. The hospital convalescence seldom exceeds three weeks comparing favorably with the minimum of eight weeks' close supervision and three or four separate procedures involved in the Mikulicz procedure.

Cattell and Colcoek, from the Lahey Clinic, in summarizing their experience with congenital megacolon state that "Congenital megacolon is rare. Six patients have been operated upon at the Lahey Clinic from 1940 to 1945 inclusive and are reported. The operation of choice is segmental or subtotal colectomy. Lumbar sympathectomy as the only operative procedure offers little chance of permanent relief and if employed should be reserved for the milder cases with diffuse dilatation. Medical treatment should suffice for these cases without operative intervention. Lumbar sympathectomy may be combined with segmental resection but should not accompany subtotal colectomy."



## CASE REPORT

R. F., Case No. 1515, male, age three years, referred to my service by Dr. H. Loikrec on January 5, 1946, with a chief complaint of "constipation." He was well up to the age of six months when he began having trouble evacuating his bowels. Constipation varied from one week to six months, the length of the latest episode, the use of laxatives and enemas being of no value. Along with constipation there was nausea and vomiting occurring with severe abdominal pain and marked abdominal distention. About four months ago the mother noticed a mass in the child's abdomen varying in size after enemas or vomiting, the enemas never resulting in formed stool and yielding only discolored fluid. The past medical history was otherwise negative.

Physical examination revealed a well nourished male child. The tonsils were hypertrophic, dentition good and some palpable nodes present in both post-cervical chains. The heart and lungs were essentially negative. The abdomen revealed moderate distention and a slight umbilical hernia. Palpation revealed a rounded, hard, firm mass extending to the umbilicus. Rectal examination disclosed a greatly dilated rectum with a massive fecal impaction which on bimanual examination seemed to be the source of the large abdominal "tumor."

On January 6, 1946, under vinethene anesthesia the impaction was broken up and a barium enema administered under fluoroscopic control, the enema visualizing a large dilated sigmoid flexure. Unfortunately due to hyperirritability of the colon, after breaking up the impaction, the barium was not retained long enough to be recorded on a film, only a faint residue of barium visualizing the upper portion of the sigmoid. Three days later the retained barium visualized the lower portion of the descending colon and rectum and a composite photograph of the superimposed x-ray films revealed the extent of the dilated bowel suggesting megacolon.

Other laboratory data were as follows: On January 14th the urine was clear, straw colored; specific gravity 1016, reaction acid, sugar negative, albumen very faint trace, blood negative, microscopical examination negative. Two days later erythrocytes numbered 4,170,000, leukocytes 5,000, hemoglobin 80 per cent, polymorphonuclears neutrophils 51 per cent, eosinophils 1 per cent, small lymphocytes

5 per cent, medium lymphocytes 34 per cent, large lymphocytes 6 per cent, large mononuclears 3 per cent. Kolmer and Kahn tests were negative.

On January 13, 1946, he was placed on a preoperative routine consisting of sulfasuxidine 1 Gm. four times daily,  $\frac{1}{2}$  ounce of mineral oil at bedtime and a daily colonic irrigation with normal saline solution. A daily liquid evacuation resulted from this routine. Donors were obtained by proper crossmatching and held in abeyance for the day of operation. Caster oil,  $\frac{1}{2}$  ounce was given forty-eight hours before operation and the enema omitted the day before operation.

On January 19th, he was operated upon using ether vapor and oxygen for anesthesia and a continuous drip of blood through a cannula inserted into the internal saphenous vein at the left ankle joint. Through a lower midline incision the dilated sigmoid was resected from its junction with normal sigmoid down to the rectosigmoid junction. An open end-to-end anastomosis was carried out in two layers using No. 00 chromic interrupted sutures for the inner layer and interrupted No. 35 stainless steel wire for the outer layer. There was no fecal matter visible during the anastomosis. The posterior peritoneum in front of the bifurcation of the aorta was opened and a dissection of all fat and areolar tissue carried out to sever the presacral nerve;  $2\frac{1}{2}$  Gm. of sulfanilamide powder was sprinkled over the anastomotic suture line and the abdomen closed by a continuous No. 00 chromic suture doubled for the peritoneum and interrupted black silk sutures approximating the skin, subcutaneous tissue and fascia as a single layer.

The total operating time was sixty-five minutes with the patient's condition very good on leaving the table. A total of 500 cc. of citrated blood was administered during the operation and in the immediate postoperative period.

Penicillin was started immediately postoperatively in 10,000 units intramuscularly every third hour and increased to 30,000 units on January 21st, continuing until January 26th, when it was discontinued. Fluids were administered by vein through the cannula until January 21st, when water was started by mouth and sulfasuxidine again started giving 1 Gm. every four hours and continued until January 24th.



FIG. 1. Composite x-ray picture after barium expulsion showing degree of involvement.

The temperature reached normal on the sixth postoperative day and liquid bowel movements were passed as soon as sulfasuxidine was started postoperatively. The patient left the hospital on the thirteenth postoperative day in good condition.

A complete blood count on January 25th, revealed erythrocytes 4,370,000, leukocytes 10,450, hemoglobin 80 per cent, polymorphonuclears neutrophils 61 per cent, eosinophiles 3 per cent, basophiles 6 per cent, small lymphocytes 25 per cent, medium lymphocytes 3 per cent, and large lymphocytes 2 per cent.

A summary of the pathological report is as follows: Macroscopic: "The specimen consisted of large intestine measuring 20 cm. in

length. At one end it measured 2.8 cm. in diameter and at the opposite end 4.9 cm. The portion of smaller caliber comprised two-thirds of the specimen and had prominent teniae and small sacculations which appeared normal. The dilated portion while it had a thickened wall had no teniae or sacculations."

Microscopic: "Sections of large intestine were lined by a typical mucosa which was somewhat more deeply stained and basophilic than usual. The muscularis was very well developed and appeared to be three or four times the usual thickness. The individual smooth muscle fibers were large and even with a simple H. & E. stain it was evident that the myoglia fibrils were very large and promi-

nent. No inflammatory cell infiltration was seen. In the submucosa there was an occasional small germinal lymph follicle." Diagnosis: Congenital megacolon. (Hirschsprung's Disease) hypertrophy of colon.

A follow-up examination July 8, 1946, revealed a well nourished healthy youngster having no abnormal symptoms or complaints and normal stool evacuations without need of laxatives or enemas.

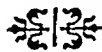
#### SUMMARY

In considering the treatment of megacolon it may be stated that with preoperative preparation of the large bowel with sulfasuxidine it is possible to perform primary anastomosis on a practically empty colon and devoid of fear of postoperative peritonitis and intestinal fistula. The general condition of the patient is enhanced by the free use of blood transfusions and postoperative penicillin which has an inhibitory effect on anerobic streptococci and clostridial infections and the prevention of their causitive rôle in postoperative peritonitis. Thus this negligible surgical mortality will stimulate the more frequent use of surgery in the treatment of congenital megacolon replacing protracted medical treatment and its final high mortality rate as well as the operation of sympathectomy which besides its fre-

quent failure sometimes by interrupting visceral sensory pathways fails to warn the patient of impaction or impending perforation.

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# SUBMUCOUS LIPOFIBROMA OF THE ILEUM

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**B**ENIGN tumors of the small intestine are rarely found and are still less frequently diagnosed clinically. It is likely that their frequency is greater than is found at operation for many are discovered as incidental findings at autopsy. Kirshbaum,<sup>1</sup> in 1935, reported nine cases of lipoma of the gastrointestinal tract discovered at autopsy, six of which were located in the small intestine. Two of these were associated with clinical symptoms. In his analysis of thirty-three benign tumors encountered in 5,754 autopsies, twelve were in the small intestine. Schottenfeld,<sup>2</sup> in 1943, reviewed the literature and presented six new cases of lipoma of the small intestine. In his review he pointed out that of forty-six gastrointestinal tract lipomas discovered in a total of 38,741 autopsies sixteen were in the small bowel.

Benign tumors of the small intestine may affect all parts of the jejunum and ileum; however, they are most frequently found in the ileum (Kirshbaum, Maingot,<sup>3</sup> Lichtenstein and Dutra<sup>4</sup>). Schottenfeld, in his review of 275 gastrointestinal tract lipomas, stated that 56.0 per cent were in the small bowel, 52.0 per cent of which were in the ileum. The commonest types of benign small bowel tumors in order of their frequency are adenoma, myoma, fibromyoma, lipoma and hemangioma.<sup>5</sup> Rarer types are the lymphangioma, angiofibroma,<sup>4</sup> myxofibroma<sup>6</sup> and neurofibroma.

The tumors may be submucous or subserous, sessile or polypoid. Their symptoms vary with their origin. Generally the subserous types growing in an extraluminal direction present no symptoms. The sub-

mucous types may be symptomatic. These may cause melena, intussusception, partial or complete obstruction of the bowel and necrosis of the tumor mass.

These findings are usually the complications of the polypoid type of lesion rather than the sessile type.

Clinically the patient may present a picture of acute or chronic attacks of intestinal obstruction associated with moderate to marked abdominal distention, nausea, vomiting and weight loss. Blood may be found in the stool. Christopher,<sup>7</sup> in 1942, reported a case of hemangioma of the ileum in which recurrent melena was a prominent finding. Smith, Good and Gray,<sup>8</sup> in 1944, reported two cases of tumor of the small bowel that was responsible for intermittent episodes of melena over a period of three and seven years, the former a malignancy and the latter a benign lesion.

Diagnosis may be made by a history of the tendency toward recurrence of symptoms, mainly constipation, abdominal distention, melena, nausea, vomiting and weight loss.

## CASE REPORT

A Mexican male, aged forty-seven years was admitted to a medical service of the Cook County Hospital on December 10, 1945 with the diagnosis of "cirrhosis of the liver." He presented the following complaints: weakness, progressive fatigue, intermittent, recurrent attacks of vomiting, a weight loss of 30 pounds, occasional tarry stools and abdominal swelling of three months' duration. There was no previous operation.

Physical examination on that date revealed a weakened, middle-aged Mexican male, show-

ing evidence of recent weight loss but no distress. The temperature was 98.2°F., the pulse 70, respiration 20 and the blood pressure 100 systolic and 60 diastolic. The skin was wrinkled. The pupils were small and unequal and did not react to light. The heart was slightly enlarged to the left but no murmurs were heard.

The abdomen was slightly distended and there was little tenderness in the right upper quadrant. No masses were palpated. The kneejerk reflexes were absent. A tentative diagnosis of cerebrospinal lues and gastrointestinal tract malignancy was made.

The red blood cell count was 4,700,000 and the white blood cell count 9,250 with 76 per cent polymorphonuclear leukocytes, 21 per cent lymphocytes and 3 per cent monocytes. The hemoglobin was 92 per cent. The urine was acid, negative for sugar, albumin or cellular elements. The blood Wassermann was negative. The blood non-protein nitrogen was 29 mg. per hundred cc. The inorganic phosphorous was 2.7 mg., the alkaline phosphatase 4.3 units (Bodansky) and the acid phosphatase 0.7 units per hundred cc.

X-ray examination of the chest revealed a boot-shaped heart. A scout film of the abdomen showed gaseous distention in the small bowel with early ladder effect. A barium enema on December 19th was negative. A roentgenological diagnosis of "small bowel obstruction" was made.

The patient continued to have daily bowel movements and was comfortable until December 30th when he developed abdominal cramps, became markedly distended and vomited several times. Visible peristaltic waves were noted concomitant with the cramps. Auscultation revealed rushes, tinkling and borborygmi. The patient was transferred to surgery.

On December 31st under spinal anesthesia the patient was explored. The peritoneal cavity contained a moderate amount of clear serous fluid. The small bowel was markedly distended. About two feet proximal to the ileocecal junction an ileoileal intussusception was found. When this was reduced a mass was noted in the lumen of the bowel which was distended proximal to the mass. The mass and approximately 25 cm. of the ileum were resected and an end-to-end anastomosis performed.

The patient had an uneventful recovery and was discharged from the hospital fifteen days following the operation.



FIG. 1. Gross tumor: pedunculated lipofibroma of the ileum.

The pathological report was as follows: the specimen consisted of a segment of small intestine measuring 25 cm. in length. The serosa was thickened and in places covered by fibrous tags. This was especially marked in the mid-portion of the bowel segment. The serosa was slightly injected and purplish-pink. The mid-portion of the resected bowel was deformed by

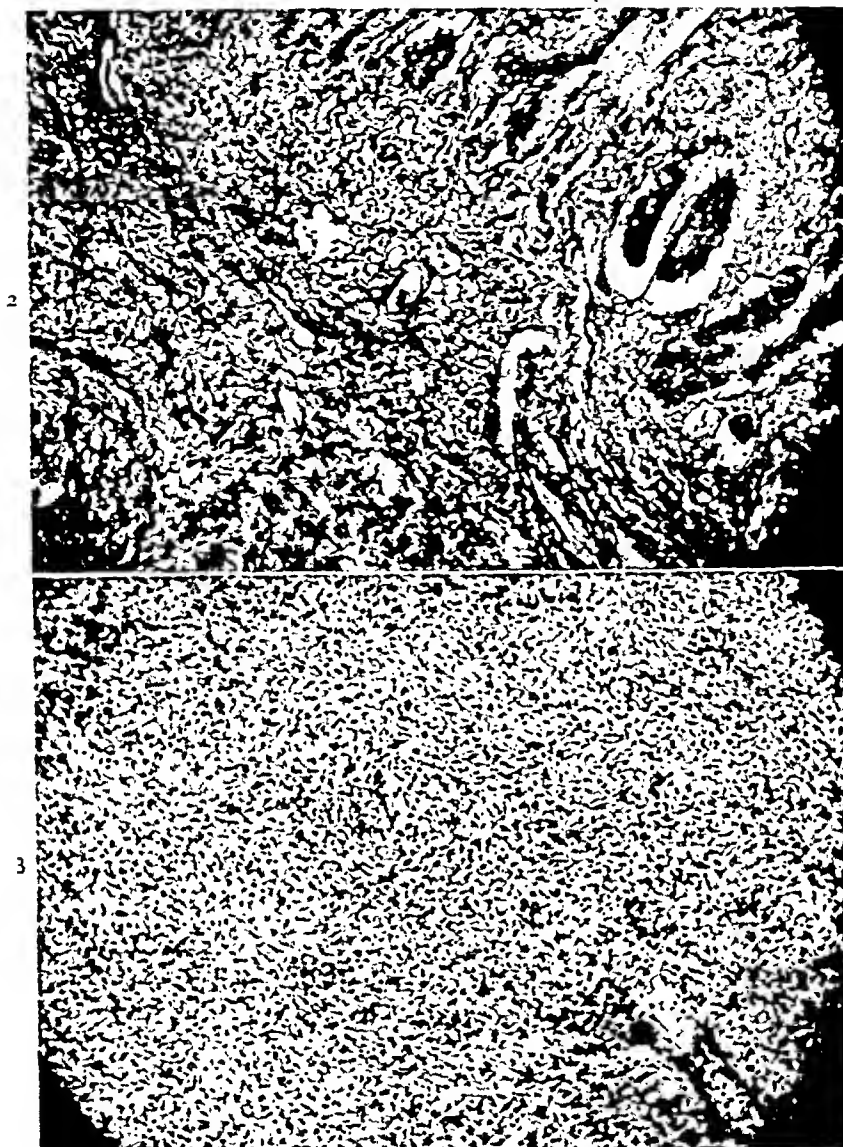


FIG. 2. Note proliferation of mature and immature fat cells in the lamina propria and submucosa; hematoxylin and eosin stain;  $\times 172$ .

FIG. 3. Note interlacing bundles of cellular fibrous connective tissue and scattered fat cells; hematoxylin and eosin stain;  $\times 172$ .

an oval shaped mass measuring 5.0 by 5.0 by 4.0 cm. which appeared to be freely moveable within the lumen.

On opening the bowel a pedunculated mass was exposed, 5.0 by 4.0 by 4.0 cm., which was attached to the mucous membrane along the lateral aspect of the wall by a pedicle 1.5 cm. long and 1.2 cm. in diameter. The mass was covered by a light tan mucous membrane. Beneath the mucous membrane were small plaques measuring up to 12 mm. which were light yellow-grey and surrounded by a reddish-grey, hemorrhagic extravasation up to 1 cm. in diameter. The remaining portion of this

pedunculated mass on sectioning was a homogeneous pale grey-white. The mucous membrane in the proximal portion of the mass was congested, purplish-red to pale purplish-grey and covered by thick mucus. The distal portion was pale purplish-grey.

The circumference of the lumen of the bowel for a distance of 3.0 cm. proximal to the mass was 4.0 c.

Proximal to this region the circumference measured 9.5 cm. Distal to the mass the lumen was 6.5 cm. in circumference.

Microscopically a section of the mass revealed large accumulations of fat cells both in

the lamina propria and in the area of the submucosa. (Fig. 2.) The cells for the most part were fat cells, characterized by the marginal placement of the nucleus along the cytoplasmic membrane and a large vacuole occupied by fat in the cytoplasm. Mixed with the mature fat cells were some less mature ones as characterized by the centrally placed nuclei and finely vacuolated cytoplasm. In the region of the muscularis propria the fat cells were less numerous, the original tissue having been replaced by interlacing bundles of cellular fibrous connective tissue. (Fig. 3.) The diagnosis was submucous lipofibroma of the small intestine.

#### COMMENTS

The above case presented several clinical features that should have suggested its diagnosis. The history of weight loss, recurrent attacks of vomiting, occasional episodes of tarry stools and intermittent abdominal swelling was strongly suggestive of a benign, obstructive lesion. Malignancies as a rule are progressively rather than intermittently obstructive. The chronicity of the intussusception was apparent by the evidence of multiple fibrous tags. Although recurrent melena has been usually attributed to necrosis of the tumor proper, it is to be noted that no evidence of such necrosis was present in this patient. Very likely the intermittent occurrence of melena can be explained by the chronicity and no

doubt recurrent acute attacks of intussusception, the last attack necessitating surgical intervention.

#### SUMMARY

A case of submucous lipofibroma of the ileum associated with intussusception was reported. The history, symptomatology and physical findings were typical of those found in similar cases. The patient recovered after surgical resection of the involved bowel and an end-to-end anastomosis.

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# FOREIGN BODY PERFORATION OF THE SIGMOID SIMULATING CARCINOMA\*

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IN 1941, MacManus<sup>1</sup> collected ninety-three cases of foreign-body perforation of the intestines from the literature and added two of his own. He found three main types of foreign bodies: (1) The metallic type including pins, wires and screws, was most common (46 per cent), (2) bones were encountered nearly as often while (3) wood splinters, including toothpicks, made up only 9 per cent of these cases.

According to Carp,<sup>2</sup> who reviewed all the cases of this nature admitted to the New York Presbyterian Hospital from 1915 to 1926, the great majority (83 per cent) of ingested foreign bodies are passed through the body harmlessly. A small proportion (17 per cent) become lodged and result in perforation; these figures suggest that innumerable cases never reach the hospital.

The clinical picture in these collected cases of intestinal perforation falls into two main types: usually the symptoms are fairly acute, the duration ranging from a few hours to two weeks. In one-third of the cases, however, the symptoms and signs develop gradually and are characterized by low grade fever and anorexia. In the case of radiolucent bodies, the preoperative diagnosis is usually impossible especially since the ingestion of the foreign body is rarely remembered. Only one case in MacManus's entire group of ninety-five had any knowledge of the ingestion of the foreign body.

The gross pathologic findings fit into five main groups.<sup>1</sup> In order of their frequency these are: (1) abscesses, forty-two; (2) generalized peritonitis, eighteen; (3) early localized peritonitis, seventeen; (4) indurated inflammatory tumors, fourteen and (5) hemorrhage, one. Perforation of the appendix occurred in thirty-four of these

patients while sigmoid perforation occurred in only five. In sixty cases reported since 1900, there was a 10 per cent mortality.

The case we report of perforation of the sigmoid by a toothpick is of particular interest because of the chronic clinical course, the roentgenogram which simulated carcinoma and the peculiar gross pathologic condition of the lesion.

## CASE REPORT

A fifty-six year old housewife was admitted to the Beth Israel Hospital on November 24, 1946, with the chief complaint of abdominal pain and constipation of ten weeks' duration. Ten weeks previously, she was seen at her home complaining of mild, "cramp-like" lower abdominal pain associated with nausea and chilly sensations. She related the onset of her symptoms, then of twenty-four hours' duration, to a meal of fish eaten two days before. She had no bowel movement for twenty-four hours. Examination revealed slight tenderness to the left and below the umbilicus, no associated spasm and a temperature of 99.2°F. A presumptive diagnosis of acute diverticulitis was made. Three days later, September 18, 1946, because of the persistence of her symptoms, she entered a local hospital.

Her laboratory findings on admission were: white blood cells, 13,500; polymorphonuclears, 85 per cent; red blood cells, 3,800,000; hemoglobin, 75 per cent and urine, normal. A barium enema showed a constant area of narrowing at the junction of the sigmoid and the descending colon which was not characteristic of carcinoma; the mucous membrane appeared intact. The patient was treated for threatened peritonitis and was maintained on intravenous fluids and given a course of sulfasuxidine. Her temperature ranged between 98.8° and 99.8°F. She was discharged after one week, apparently well, on a vitamin supplemented low residue diet. When seen two weeks later, she continued to complain of gaseousness and "pencil shaped

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FIG. 1. Roentgenogram showing area of narrowing at junction of descending colon and sigmoid.

stools." Sigmoidoscopy showed considerable mucus in the sigmoid but no blood; the stenosis was beyond the area visualized. No further medical attention was sought until 5 A.M., October 20th when her temperature rose to 105°F. after a shaking chill. Pain developed in the left lower quadrant radiating down the left leg; vomiting was continuous. The patient was readmitted to a local hospital with a diagnosis of "Sigmoiditis, with retroperitoneal perforation." Examination revealed tenderness over the sigmoid. There was a tender bulge in the left vault upon pelvic examination. The white blood count was 37,000. Penicillin and streptomycin were given simultaneously with prompt subsidence of leukocytosis, fever and pain. On the third hospital day, daily rectal irrigations containing sulfasuxidine were begun to relieve the obstipation. She was discharged on her fifteenth hospital day after four days of a normal temperature and no medication. At home the lower abdominal pain and constipation recurred and, three weeks later, she was hospitalized at the Beth Israel Hospital.

The physical examination disclosed a short, obese patient in no distress. There was mild ten-

derness over the sigmoid and tenderness and fullness in the left pelvic vault. The temperature, pulse and respirations were normal.

The admission laboratory data revealed a negative urine; white blood cells, 6,850; red blood cells, 3.5 million; hemoglobin, 75 per cent and stools, guaiac negative.

During the clinical course the previous x-rays were reviewed; and a repeated barium enema revealed "an area of narrowing in the sigmoid about 3 cm. long. The findings were those of an organic lesion in the mid-sigmoid, slightly stenotic. Some features of the lesion were suggestive of an inflammatory nature. However, carcinoma could not be definitely ruled out." The patient was seen by two consultants, a gastroenterologist and a surgeon; both agreed that malignancy seemed the most likely diagnosis. The large bowel was prepared for surgery and on the eleventh hospital day laparotomy was performed under continuous spinal anesthesia.

A left rectus splitting incision was made extending from the symphysis to 1 inch above the umbilicus. Exploration of the upper abdomen revealed no abnormalities. The sigmoid

lay deep in the pelvis where it was fixed to the posterior uterine wall and broad ligament by a hard mass which felt like carcinoma. A loop of distal sigmoid was felt beneath the mass and, because of the possibility of palliative resection, a plane of cleavage was developed by blunt dissection between uterus and involved bowel. A few drops of purulent material were encountered. The bowel, which was adherent over an area 8 by 4 cm. to the uterus and left ovary, was separated with relative ease and revealed an unusual orange-yellow coating to the "abscess cavity" and adjacent bowel wall. A portion of this was taken for frozen section and reported as showing "chronic inflammation." A corpus luteum cyst 3 by 2 cm. lay in the upper portion of the mass. As the cyst was being separated from the sigmoid a small communication between it and the bowel wall was uncovered and a 3 cm. piece of toothpick extruded itself. After mobilization of the bowel the lesion was found to involve the junction of the descending colon and sigmoid. A large redundant loop of sigmoid had been trapped beneath the lesion in the pelvis. An additional biopsy taken from the hard yellow material at the mesenteric border of the bowel, away from the ovary, confirmed the first report. A left salpingo-oophorectomy was performed. The tiny (0.2 cm.) sigmoid perforation was closed. Two Gm. of sulfanilamide powder were sprinkled in the pelvis and over the bowel. The omentum was then tacked down with interrupted sutures over the long denuded area on the bowel and several appendices epiploica were used to peritonealize the posterior surface of the uterus. The abdominal wall was closed in layers without drainage. The patient left the operating room in good condition.

The pathological examination revealed that the specimen consisted of a resected left tube and ovary. The ovary measured 3.0 by 2.8 by 2.3 cm. while the tube measured 3.5 cm. in length and 0.6 cm. in diameter at the ampulla. The external surface of the specimen was covered by congested and somewhat roughened peritoneum except at the upper pole of the ovary where a cystic cavity opened to the outside. This cavity measured 3.0 cm. in diameter; its inner surface was yellowish-gray in color and covered to a great extent by reddened and necrotic material. The wall of this cystic structure was relatively thick, measuring 0.35 cm. in average thickness. Beneath this cyst definite ovarian tissue could be recognized containing a few tiny corpora lutea. The

fimbriated end of the tube was patent, yet swollen and congested. Also submitted was a thin sliver of wood resembling a portion of toothpick which measured 2.8 cm. in length. This body had been removed from the cyst of the ovary. There were a few small, irregular fragments of reddened and light yellowish-tan, friable tissue measuring 0.6 cm. in diameter. Frozen section showed inflammatory tissue with foreign body giant cells surrounding double refractile bodies.

Diagnosis: Chronic oophoritis with necrosis, cystic and xanthomatous degeneration; perioophoritis and perisalpingitis; perisigmoiditis; foreign body (wood sliver) and hydrosalpinx.

The patient's postoperative course was uneventful. She was given penicillin and streptomycin. Her temperature rose to 101°F. on the second postoperative day but fell within three days and remained at 99°F. throughout her stay. This slight elevation was attributed to residual pelvic inflammation. Antibiotics were withdrawn after one week. She was discharged on the eleventh postoperative day (December 14, 1946) with her wound well healed. Three days after discharge, she again began to complain of abdominal cramps and fever. She was readmitted December 24, 1946, with a temperature of 100°F., a white cell count of 16,000 and a diagnosis of "pelvic abscess." Massive doses of penicillin made drainage unnecessary. She was discharged January 16, 1947, after one week of normal temperature without chemotherapy and has remained well ever since.

#### SUMMARY

A case history is presented of a patient in whom a swallowed fragment of toothpick perforated the sigmoid and entered a corpus luteum cyst of the left ovary. The prolonged symptomatology, anemia and x-ray evidence of an obstructive lesion led to a preoperative diagnosis of carcinoma of the sigmoid. At operation the perforated bowel and ovarian cyst were found involved in a hard yellow mass. Tissue from the mass revealed a unique reaction due to the response of the lutein cells to chronic irritation.

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# ENDOMETRIOSIS OF THE UMBILICUS\*

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THIS paper is written for the purpose of adding two cases of endometriosis of the umbilicus to this relatively rare entity and also to review some of the literature on this subject.

Novak<sup>1</sup> states that about forty cases of endometriosis of the umbilicus have been reported. However, according to Berman,<sup>2</sup> Stranger found a total of sixty-eight cases reported in the entire world until the end of 1935.

Since 1935, we found that in American literature Jenkins and Brown<sup>3</sup> reported only three cases of endometriosis of the umbilicus out of a total of 117 cases of endometriosis elsewhere in the body. Fallon, Brosman and Moran<sup>4</sup> reported 200 cases of endometriosis in a recent article but failed to mention any cases involving the umbilicus.

Green<sup>5</sup> in 1899 was among the first to describe a case whose history and physical findings were very suggestive of endometriosis of the umbilicus and Cullen<sup>6</sup> in 1920 reported two cases. Samson<sup>7</sup> in his very thorough and interesting article discusses endometriosis or adenoma of the peritoneal cavity but makes no mention of endometriosis elsewhere in the body.

*Histogenesis* There are a number of theories concerning the histogenesis of endometriosis of the umbilicus. We are in agreement with Meyer, Novak and others that the Sampson theory of regurgitation of endometrial particles through a tube does not explain endometriosis of the umbilicus because, as previously mentioned, Sampson did not take into consideration endometriosis outside of the peritoneal cavity.

We found in our cases, as did Berman<sup>2</sup> and others, that no communication existed

between the peritoneal cavity and the umbilicus and there were no signs of endometriosis elsewhere. Therefore, the celomic metaplasia theory seems to be the most logical explanation for the subject on hand. This theory, by Ivanoff and Meyer, is based on the fact that the entire epithelial apparatus of the female genital tract is derived from the primitive peritoneum which forms the epithelial lining of the celomic cavity. The müllerian duct is developed from the invagination of this celomic epithelium and remnants of this remains at the umbilicus and undergo endometrial differentiation.

Bingham and Templeton<sup>8</sup> state that while endometriosis is not malignant, these growths have been known to recur and metastasize. Visible endometrium has been found in the pelvic lymph nodes on numerous occasions and, according to Berman, cases of endometriosis of the arm and thigh have been reported.

## CASE REPORTS

CASE 1. R. M., (No. 113538), a thirty year old colored female, was admitted to the Surgical Service of Harlem Hospital on January 29, 1939, with a history of umbilical "tumor" of one year's duration. It was painful and bled intermittently for a month prior to admission. There was no periodicity to the pain. The past history revealed that the patient had had a hysterectomy for fibroid uterus followed by amenorrhea three years prior to admission.

The physical examination revealed a well developed and well nourished colored female in no acute distress. Her head and neck showed no gross abnormality. The lungs were clear and the heart was essentially negative. The abdomen was scaphoid and there was a well healed lower mid-abdominal scar present. There were no palpable masses. The umbilicus

\* From the Surgical Service of Harlem Hospital, New York City, Dr. Louis T. Wright, Surgical Director.

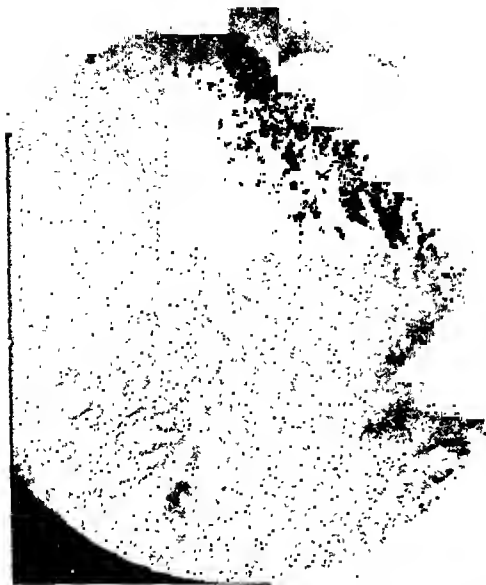


FIG. 1. Showing skin, appendages within the superficial portion of cutis and nests of endometrial glands in the deeper portions.



FIG. 2. Presents a higher magnification of Figure 1, showing endometrial glands in secretory phase surrounded by endometrial stroma.

showed a bluish discoloration with tumor formation in the center, tender and cystic in character. The admitting diagnosis was (1) umbilical tumor and (2) possible hemangioma.

At operation on January 20, 1939, an umbilectomy was performed. A discoloration was found to extend to the peritoneum; however, no intraperitoneal involvement was present.

The postoperative course was uneventful except for several episodes of stuporous and semi-stuporous states due to hysteria. The patient was discharged on the eighteenth post-operative day in excellent condition.

The pathologic report is as follows: Gross: The specimen consisted of skin and subcutaneous tissue in the center of which the umbilicus was found. The skin measured 11 by 4 cm. The umbilicus had a raised, light purplish mass in its center. On cut section, the mass was seen to consist of fibrous tissue. Microscopically, sections of the tumor revealed endometriosis of the umbilicus.

CASE 11. G. R., (No. 239484), a thirty-four year old colored female, was admitted to the Surgical Service of Harlem Hospital on November 9, 1945, complaining of painful swelling of the umbilicus of two years' duration. The pain was most severe during her menstrual periods and became progressively worse. The periods were regular, every twenty-eight days and last-

ing for four days, with no dysmenorrhea or menorrhagic. There was no history of external bleeding. The patient had one child and no miscarriages.

The physical examination revealed a well developed and well nourished colored female in no acute distress. The head and neck showed no gross abnormalities. The lungs were clear and the heart was essentially normal. The abdomen was obese and non-tender. The umbilicus was enlarged, tender, with a small area of ulceration in the center. There was no gross evidence of bleeding. The pelvic examination was essentially negative.

The admitting diagnosis was (1) endometriosis of the umbilicus and (2) omphalitis. Five days after admission, the pain in the umbilicus became severe and the umbilicus showed a small clot in the center.

On November 27, 1945, fourteen days after admission, an umbilectomy and incidental appendectomy were performed. The essential findings at the operation were as follows: The umbilicus showed ulceration with blood clot in the center and purplish discoloration extending to the peritoneal surface. However, the peritoneal cavity revealed no endometrial implants. The uterus was two to three times the normal size and boggy (premenstrual).

The postoperative course was uneventful and the patient was discharged, symptom-free, on the thirteenth postoperative day.

The pathologic findings were as follows: Gross: The specimen consisted of a mass of tissue 6 by 3 by 2 cm. in the center of which was an ulceration with a purplish discoloration. The microscopic section revealed endometriosis of the umbilicus.

*Comment.* These two patients were admitted to the surgical wards of this hospital instead of to the gynecologic wards without the correct diagnosis being made. It seems worth while, therefore, to call the attention of the surgeons, who do not do gynecologic work, to this simple but unusual condition. In one instance it was mistaken for a tumor; in the second instance it was mistaken for omphalitis.

Endometriosis of the umbilicus has never been reported in patients under the age of puberty and past the menopause. It is most prevalent in the third and fourth decades of life. Diagnosis of endometriosis of the umbilicus can usually be made without difficulty based on a history of painful swelling of the umbilicus most severe during, before, and/or after the menstrual period. Frequently, vicarious menstruation from the umbilicus is elicited. The most prevalent physical findings are a swollen, tender mass in the umbilicus with discoloration (purplish or bluish) and occasionally the presence of blood or a clot in the center.

Treatment consists of excision of the umbilicus. However, for cosmetic affect, and for no other reason, sterilization is

indicated. We believe that this procedure would then cause a recession of the signs and symptoms as it does in endometriosis of the peritoneal cavity.

#### SUMMARY

1. Endometriosis of the umbilicus is a relatively rare entity, sixty-eight cases being reported until the end of 1935.
2. Review of some of the literature is presented.
3. Histogenesis of endometriosis of the umbilicus is discussed.
4. Two cases are presented with a description of surgical and pathologic findings.
5. It is important for surgeons to keep this condition in mind.
6. The characteristic history and physical findings are given.
7. Treatment is suggested.

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# CONGENITAL DIAPHRAGMATIC HERNIA IN THE NEWBORN WITH MEDIASTINAL DEFECT

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THE following case presented an unusual congenital mediastinal defect associated with a posterolateral defect of the left diaphragm. Early operation produced a satisfactory outcome.



FIG. 1. X-ray showing absence of gas in abdomen, except descending colon, with intestinal pattern in left chest and superior portion of right chest and mediastinal displacement to right.

## CASE REPORT

A baby girl, M. B., was born at 11:30 P.M. on March 13, 1946, at the Methodist Hospital, Brooklyn, New York. The antepartum course and delivery were normal. The delivery was not spontaneous, the first and second stage of labor lasting six and one-half hours. The baby was a healthy infant, weighing 6 pounds 6 ounces.

About three hours postpartum, the infant's color became dusky and a deep cyanosis with labored respiratory effort gradually developed. The baby was placed in an atmosphere of 90 per cent oxygen which eased the respirations. All attempts at feeding were regurgitated.

The infant appeared normal except for

cyanosis and the marked play of the accessory muscles of respiration. The cardiorespiratory examination was unusual. There were absent breath sounds over the entire left and the right anterior chest; breath sounds were present over the right chest posteriorly. Occasional intestinal borborygmi were audible over the left chest. The cardiac sounds were best heard to the right of the midline and were normal. The abdomen was flat to percussion. Rectal examination was normal and revealed meconium on the finger.

An x-ray study, as shown in Figure 1, was reported as follows: "The entire left chest is filled with abdominal viscera. The upper portion of the right chest contains intestines. The heart and mediastinum are displaced markedly to the right. There is a very small amount of lung tissue visible in the lower half of the right lung field. Most of the gastrointestinal tract is in the chest, except for descending colon and rectum."

The presence of the intestinal pattern in the left chest suggested the usual posterolateral defect of the left diaphragm. The intestinal pattern seen in the right chest indicated a possible defect in the anterior mediastinum. The report of a definitely proved case by Ochsner et al. suggests that this defect may be a complete absence of the anterior mediastinum or possibly pleura, intravening as a hernial sac. The above report is a study of the embryologic and clinical aspects of this unusual congenital anomaly. The artist's conception of the defects present in this baby is shown in Figure 2.

The infant was carefully prepared for operation thirty hours after birth. It was carried out under open drop ether, using positive pressure anesthesia during the period of expanding the left lung. A preliminary left phrenic nerve crush was done.

The abdominal approach was used. The technical procedures employed were essentially those recommended by Ladd and Gross.<sup>2</sup> The only abdominal viscera present on inspection of the peritoneal cavity were the liver, descend-



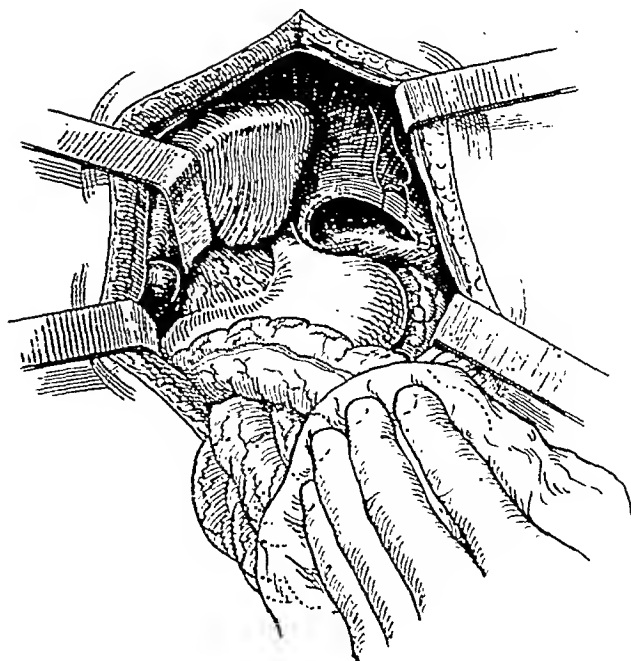
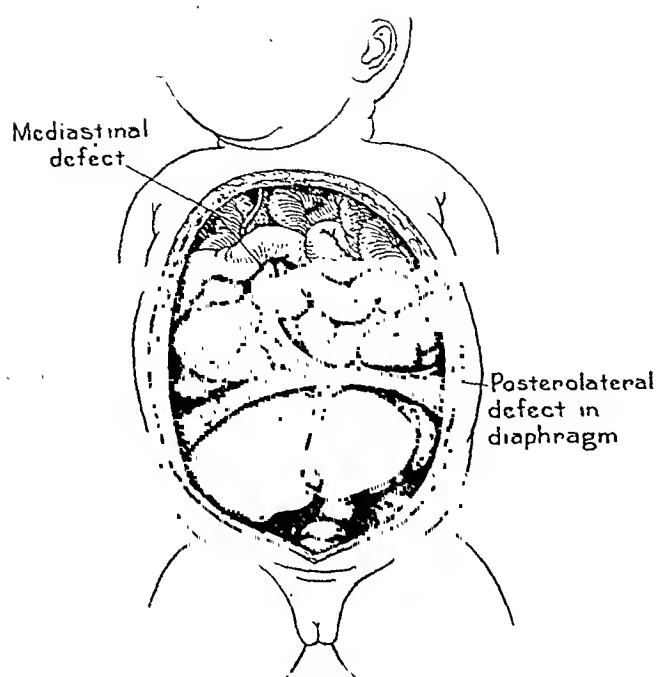


FIG. 2. Artist's conception of posterolateral diaphragmatic defects and anterior mediastinal defect.

FIG. 3. Schematic drawing showing intestine removed from peritoneal cavity and posterolateral defect without posterior left present. (After Ladd and Gross.)

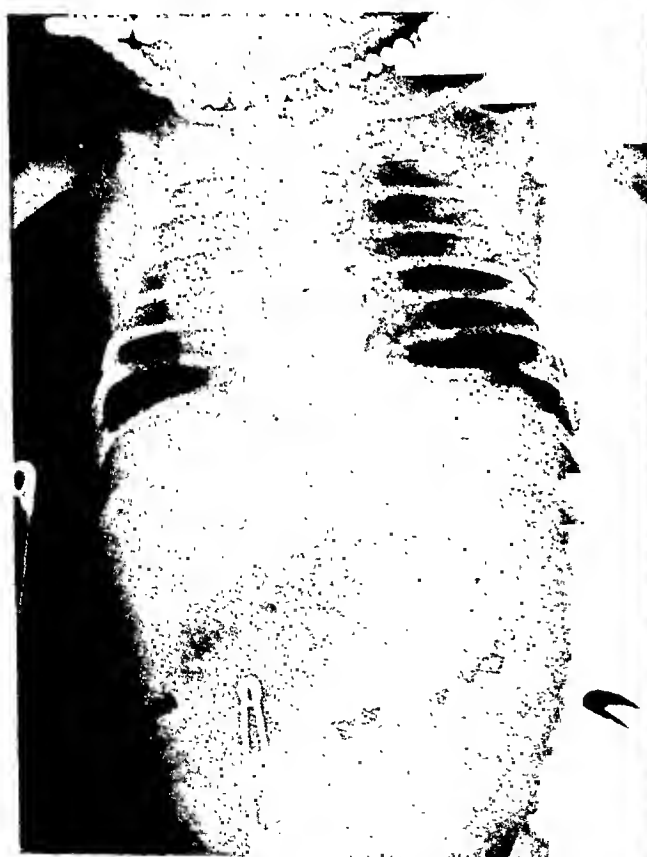


FIG. 4. X-ray of chest and abdomen, first postoperative day. Normal intestinal pattern in abdomen, air in both thoracic cavities and heart and mediastinum still on the right.

FIG. 5. X-ray of chest and abdomen on tenth postoperative day. Heart and mediastinum in normal position, both lungs expanded; intestinal pattern in abdomen normal.

ing colon and rectum. The remainder were in the right and left chest, having traversed there through the posterolateral defect in the left diaphragm. A catheter was thrust through the defect in the diaphragm and passed up to the apex of the left pleural cavity. Thus the left intrapleural pressure was made equal to the atmospheric pressure and markedly facilitated the removal of the abdominal viscera from the right and left thorax. All the viscera were then brought out on the anterior abdominal wall (Fig. 3) and the rent in the diaphragm closed as illustrated. In this case, no posterior leaf was found as is seen in the posterolateral defects. An attempt was then made to expand the left lung by positive intratracheal pressure. Air was sucked from the left pleural cavity through a catheter around which a purse-string suture had been placed in the diaphragm. It was possible to close the abdomen in anatomic layers.

The postoperative course was uneventful. A 50 cc. blood transfusion was given immediately and penicillin, 10,000 units every three hours for twenty four hours, was administered prophylactically. The left lung did not entirely expand nor did the right. There was air in both thoraces, a proof of a mediastinal defect. (Fig. 4.) On the tenth postoperative day, both lungs were fully expanded. (Fig. 5.)

The infant was discharged on the fourteenth day after operation, having regained its birth weight, and has developed normally since.

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*Announcement:* The American Association for the Study of Goiter will meet at the King Edward Hotel, Toronto, Canada, May 6, 7 and 8, 1948. The program for the three-day meeting will consist of papers dealing with goiter and other diseases of the thyroid gland, dry clinics and demonstrations.

# PRESENCE OF CECUM AND APPENDIX IN SCROTUM IN LARGE INDIRECT INGUINAL HERNIA

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THE purpose of this paper is to present a case in which the cecum and the appendix were found in the scrotum in a large inguinal hernia.

That the appendix itself has been found in a hernial sac has long been known. Ryan, in 1937, presented figures showing that of 8,692 cases of appendicitis, eleven or .13 per cent were in the hernial sac. Coley found that of 2,200 hernias operated that the appendix was found seventeen times in the sac, an incidence of 8.10 per cent.

That the presence of the cecum and the appendix in a hernial sac is rare is found by scanning the literature. A case is herewith presented in which the cecum and the appendix were found in the scrotum in a large inguinal hernia.

## CASE REPORT

M. R., a sixty-seven year old, white male, came into the clinic complaining of right scrotal pain and cramp-like abdominal pain. Examination revealed a heavy set male, weighing about 250 pounds with a huge scrotal enlargement. The first impression was that he had a large hydrocele, but the scrotum did not transilluminate well.

He was taken to the hospital for surgery. At operation an incision was made in the lateral aspect of the scrotum extending into the right inguinal region through the skin, subcutaneous tissue and dartos. The sac was located, picked up and incised and was found to contain several loops of bowel which were replaced within the abdomen only after the internal ring, which was quite narrowed, was incised. The cecum

and the appendix were left both of which were fused with the sac wall. They were dissected free with some difficulty and in one area a portion of the sac wall had to be left attached to the cecum in order to free it. The appendix was removed and the stump was inverted. Then the cecum was replaced within the abdomen and the internal ring was closed with interrupted cotton sutures. A small hydrocele was found, and it was treated as in the Bottle operation. The hernia was repaired using interrupted cotton sutures throughout.

Postoperatively the patient did very well. His convalescence was uneventful, and he was discharged from the hospital on the tenth postoperative day.

## SUMMARY

This case is presented to show that in large inguinal hernias one may encounter the small or large bowel although the latter is not so common. In many cases the appendix may be found in the hernial sac. If the appendicitis should be acute, its differentiation from strangulated hernia may be difficult.

In appendicitis the pain may come in spasms and radiate, and in strangulation the pain is usually steady and dull and constantly increasing in severity.

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# PLASTIC RECONSTRUCTION FOLLOWING THIRD DEGREE BURN OF FOREARM

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THE following case history of recovery from third degree burn of forearm presents some interesting aspects from the viewpoints of the injury and the subsequent treatment.



FIG. 1. Appearance a few weeks following admission with moderate granulation and exposed devitalized portion of ulna.

On September 3, 1942, at 8:15 A.M., H. K. was working on a combiner, which is a machine consisting of a hot plate and an opposing spiked surface. While in the act of putting paper through the combiner, his left hand and forearm were caught between the heating plate and the spiked surface or collar. The injured person was taken to a nearby hospital where he remained for two weeks.

H. K. was then admitted on my service to the Israel Zion Hospital, Brooklyn, New York, on September 18th, the first of eight admissions; the last was on April 20, 1943.

The patient, age thirty years, had had a bilateral hernioplasty performed twenty years

previously. General examination was negative. All findings were confined to the left upper extremity. The entire length of the dorsal, ulnar and volar aspects of the left forearm were practically denuded, leaving only the radial aspect covered with skin and the proximal two-thirds of the ulna exposed. The muscle bellies of the extensor carpi ulnaris and extensor digitorum communis were already gangrenous. Sloughing was present in the tendon of the extensor carpi ulnaris, with a purulent discharge from the wound, yellowish green in color and foul smelling. The distal phalanges of the four fingers of the left hand were severely crushed.

The diagnosis was that of a third degree burn and a crushing injury of the left forearm and hand, involving the ulna, muscle bellies and tendons.

A five per cent solution of sulfathiazole was used to irrigate the wound together with powdered applications of sulfathiazole at intervals of every few days. After four weeks' hospitalization, the patient, his wound covered with an Orr dressing, was discharged from the hospital on October 18, 1942.

Then followed five readmissions for changes of the Orr dressings between November 30, 1942, and March 2, 1943, the dates being November 30th, December 12th and 22nd, 1942, and January 14th, February 13th, and March 2, 1943, respectively.

On March 19, 1943, the patient was admitted to the hospital for the seventh time, whereupon a 6 $\frac{3}{4}$  inch section of the outer portion of the distal three-fourths of the ulna, occupying about one-third to one-half of the circumference of the ulna, was removed by sequestrectomy.

On April 28, 1943, the patient again was admitted, and the next day was begun the first stage of a broad abdominal skin flap to the left forearm. The skin of the infra-umbilical region was utilized which extended from one anterior



FIG. 2. Volar aspect with healing following first and second degree burns.

superior iliac spine to the other. This free margin of the abdominal graft was sutured to the previously freshened edge along the dorsal aspect of the left forearm.

The wound having healed by primary union, all sutures were removed on the fourteenth postoperative day. Nineteen days later, the second stage was performed by severing the lower border of the broad abdominal skin flap which was then sutured to the previously freshened skin edge on the anterior aspect of the

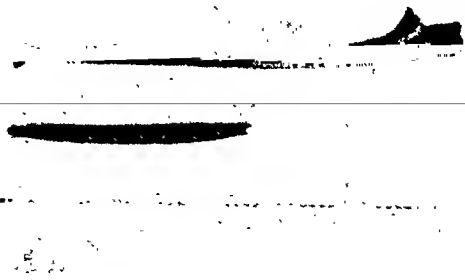


FIG. 3. Segment of removed devitalized ulna compared to a normal ulna.

forearm. As the take on the forearm proved successful, all sutures were removed eight days postoperatively.

This plastic procedure was followed within twenty-seven days by a split skin graft from the left thigh to the abdomen, the purpose of which was to cover the extensive abdominal defect resulting from the broad pedicle graft. The following procedure was used to do this split skin graft:

With the aid of paraffin mesh gauze, a pattern of the abdominal raw surface was cut out. Following preparation of the edges of the abdominal defect and using a Padgett dermatome, a section of skin 0.018 inch thick, 7 $\frac{3}{4}$  inches long and 4 inches wide was taken from the left



FIG. 4. Granulations covering area of previously resected devitalized ulna.



FIG. 5. Volar aspect of healed left forearm.



FIG. 6. Wide abdominal flap ten days after operation.



FIG. 7. Release of abdominal skin flap revealing extensive granulating surface of abdominal wall.

thigh. This oblong section was divided into two triangular grafts, corresponding to the paraffin mesh pattern, and then accurately sutured into position so that they exactly covered the defect of the abdominal skin. The surface of the graft was then pie-crusts and postoperatively the split skin graft was kept moistened with saline. Following the split skin graft, the sutures were removed eleven days postoperatively. On June 12, 1943, the patient was discharged after eighty-three days of hospital treatment, forty-four of which were devoted to the various plastic procedures.

The following results were revealed by a subsequent examination: The recipient area on the left forearm was soft and pliable and showed good color; it also adequately protected the sharp dorsal border of the regenerated ulna. This effect compared favorably with a non-grafted area of dermis in the region of the ulnar aspect of the wrist which was thin, dried, hard and sealy. The ungrafted area presented a hard, unstable sear and compared poorly with the grafted area both in efficiency and function.

The donor sites on the abdominal wall and on the left thigh had healed. There was, however, limitation of range of motion of the wrist up to 60 degrees, as compared to a normal range of 90 degrees, resulting in a one-third loss of motion range. Ankylosis of the small left finger and a firmly scarred area, measuring 1 by 4 inches along the ulnar aspect of the left wrist and hand, were present. Amputation of the

patient's ankylosed little left finger is advisable but has been deferred for a time, as it is no hindrance to his present occupation as a clerk.

The technic of the Padgett dermatone grafting process is well known to most surgeons. Nevertheless, when the bone is



FIG. 8. Split skin graft from left thigh covering defect of abdominal wall.



FIG. 9. Healed area of split skin graft.

FIG. 10. Take of graft to abdominal wall and final result of forearm graft.

superficial, the flap, as previously indicated, is desirable in order to give the bone sufficient covering. Where the flap has a wide base, similar to the one described, it is unnecessary to use a tubular graft with a consequent gain in time. The second World War has provided the opportunity of demonstrating the successful application of the above method which has proved itself a great aid in healing and time-saving. One must be cautious, however, that the base is at least as wide as its free edge.

The grafts were cut between .016 to .020 of an inch skin thickness, the latter varying with age, sex and region.

In the adult female the thickness on the inner side of the thigh measures .018 to .020 mm.

The measurement in a two to three month old infant is .010 to .012 mm.

From the abdomen of a six year old child, it is .014 to .016 mm.

In children twelve to fourteen years old, the maximum thickness is .016 mm.

Skin grafting should be done as quickly as possible after the infection has been placed under control, provided there is a clean granulating base. In the present instance, because of the devitalized ulna excised by the sequestrectomy, it was necessary for granulations to cover the ulna and the other raw surface completely before

any plastic procedure could be attempted. The broad flap pedicle graft to cover the defect of the forearm was preferred to a split skin graft so that a good thick layer of skin, together with subcutaneous elements for an exposed bony surface, could be supplied.

One of the outstanding features of the Padgett dermatone is that it permits exceptional advances in plastic surgery. By its use large skin areas of any uniform thickness may be taken from donor sites which hitherto could not be utilized. As the donor site heals sufficiently within ten to twelve days, dressings may be necessary for this period. The pressure dressings are then changed daily and kept moist with boric acid or saline solution. If necessary, the same donor site may be used again at a later period in cases of extensive burns.

#### SUMMARY

As indicated by the accompanying photographs, plastic reconstruction following a third degree burn may be successfully accomplished when the procedure employed is functionally efficient. The proper grafting of the abdominal skin flap is of the greatest importance in achieving satisfactory results and the use of the Padgett dermatone in skin removal contributes greatly to the final result.



# RECONSTRUCTION OF THE FACE AND ALL FOUR EYELIDS

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**A** METHOD of reconstruction of the face and eyelids is described which provides a covering that approximates the normal in contour, flexibility, expression and texture more nearly than that produced by other means.

## CASE REPORT

The patient, a twenty-seven year old soldier who was burned in France by a gasoline explosion in January, 1945, was admitted for treatment of severe ectropia of all four eyelids, granulating third degree burns of the whole left parietal region of the scalp and marked deformity of the face. Scars from incomplete "takes" and from the suture lines of multiple split-thickness skin grafts produced with the healed burned areas the distorted condition of the face. Shrinkage of these grafts contributed a large part to the deformity.

The eyes escaped damage at the time of the burn by reflex forcible closure of the lids. A tarsorrhaphy of both right and left lids, which was performed four days after the injury, maintained protection of the corneas and conjunctivae for a few weeks. Two months after the injury, while still at an overseas hospital, areas of free skin from the abdomen were grafted on all four lids. Although the corneas and conjunctivae were uninvolved on admission to our hospital, these skin grafts, which had served to prevent severe infection, did little toward ultimate correction of the deformities. (Fig. 1.)

Hypertrophied scars at the margins of adjoining skin grafts and scattered areas of depigmentation, where parts of the grafts had failed to grow, were with the ectropion of the right upper lip the background for the most startling feature of this face; the severe ectropia of all four eyelids with eversion and hypertrophy of the tarsal conjunctivae which were most striking manifested by closure of the eyes. (Fig. 2.)

Six days after admission to our hospital, grafts to all lids and secure tarsorrhaphies of

both right and left lids were performed. Under endotracheal inhalation ether anesthesia, a split-thickness skin graft taken from the left chest with the Padgett dermatome set at 0.015 inch was used to reconstruct the eyelids.

An arched incision was made parallel to the free lid margin in the left upper lid beginning about 5 mm. medial to the inner canthus and sweeping around laterally to a point about 12 mm. beyond the outer canthus. Considerable scar tissue which was encountered beneath the skin was dissected out and removed. In order to free the conjunctiva of the upper lid from the scar tissue contracting it, the dissection was carried back to a depth approximately equal to the equator of the eyeball. Only the margin remained of the lower lid. An incision was made parallel to and approximately 5 mm. from its border, and when all subcutaneous scar had been removed, only the conjunctiva and a few bundles of muscle fibers were left. The lids were well mobilized and each margin easily approximated its fellow.

A subtotal tarsorrhaphy was performed leaving unjoined a small central area anterior to the pupil and a similar area at each of the canthal regions. Wheeler lid sutures were used to hold the denuded lid margins together until firm union had occurred.

The previously cut skin grafts, each of which measured approximately 35 mm. in length and 20 mm. in width, were sutured with interrupted horsehair into the defects of the lids. Care was taken to follow the lines of skin tension by placing the grafts on the eyelids so that these lines were horizontal. A stent of cod liver oil-sulfathiazole gauze<sup>7</sup> and cotton "torpedo" were tied over each graft so that there would be firm, even pressure holding it in its bed. The lids of the right eye were repaired in a similar manner.

At the first postoperative dressing one week later, all of the grafts were viable and in good condition except for the loss of the medial half of the right lower lid graft. The right medial tarsorrhaphy had become separated and it was probably this that caused the partial loss of



FIG. 1. Ectropia of lower lids and right side of mouth.  
 FIG. 2. Ectropia of upper and lower lids; note hypertrophied conjunctivae.  
 FIG. 3. Ectropia of lower lids removed and right side of mouth improved.  
 FIG. 4. Eyelids close over globe with no eversion of conjunctivae.



one graft. Daily cleansing of the new surfaces with boric acid, saturated solution and zinc sulfate, 1 per cent, was performed for two weeks.

The granulation tissue on the left parietal region of the scalp was infected with *Staphylococcus aureus* and *Bacillus pyocyaneus* and remained refractory to all types of treatment until continuous soaks of a penicillin-acetic acid mixture was applied. This solution was developed and extensively used by the senior author in the preparation of infected burns for skin grafting. The mixture consisted of equal parts penicillin, 250 units per cc. and acetic acid, 1 per cent. Following application of these soaks for eight days, the granulations were clinically clean, firm, pink and healthy.

Approximately 32 sq. inches of skin cut to 0.010 inch with the Padgett dermatome was taken from the left side of the back. After the granulation tissue of the head was shaved down to the firm, yellow scar base with a Ferris Smith knife, the graft was sewed in place with interrupted No. 0000 black silk sutures. A quilting suture of the same material was placed throughout the graft and a stent of cod liver oil-sulfathiazole gauze and abdominal pad were sutured in place over the graft to maintain firm, even pressure. The donor site on the back was covered with six layers of the same kind of gauze and then a firm pressure dressing was applied to both the donor and recipient sites.

On the sixth postoperative day, all of the sutures were removed at the first dressing and the graft was found to have "taken" in entirety. The donor site was dressed for the first time on the twelfth day following operation and it was found that epithelialization was complete. Both the grafted area and the donor site were massaged several times a day with cocoa butter for two months. After three months had elapsed, fat had become deposited beneath this graft and the texture and mobility of the skin was virtually the same as that of normal scalp.

The emergency surgery having been completed on this patient, prolonged consideration was given to the best means of effecting an improvement of his facial deformity. Split-thickness skin grafts of the face in this patient, as in other similar patients whom have been observed for as long as twelve months post-operatively, have left much to be desired. When large portions of the face have been covered with even, thick split-thickness skin, we have invariably found that a waxy, expressionless, mask-like appearance results which is associ-

ated with some degree of contracture or ectropion of the orifices involved in or adjacent to the grafted area.

It was therefore decided that full-thickness skin with its own subcutaneous tissue and blood supply would provide the optimum covering for this patient's face. Since the pectoral region on one side had been used as a donor site, this readily accessible area could not be used. The only remaining symmetrical area possessing skin of the same general texture as the face was that found on the inner surfaces of the arms. It was therefore planned that a bicipital tube, which would cover half the face, would be made on each arm.

A tube  $6\frac{1}{2}$  inches long and 4 inches wide was prepared on the inner aspect of the right arm over the biceps muscle. The defect left in the skin of the arm by the formation of the tube was covered with a skin graft cut from the right thigh with the Padgett dermatome set at 0.015 inch. The graft was sutured in place with No. 0000 black silk. A quilting suture of the same material was taken throughout the graft. A stent of cod liver oil-sulfathiazole gauze and abdominal pad were sutured in place over the graft to insure proper pressure upon it. The arm was immobilized in extension with a posterior splint made of six folded hand towels.

Seven days later, all of the sutures were removed from the tube which was well healed and from the graft which had "taken" completely. No further dressings were applied but immobilization of the arm was maintained for two weeks longer so that the graft might become completely organized. Both the graft and donor sites were massaged several times daily with cocoa butter. A tube of the same dimensions was later formed on the left arm in a similar manner. (Fig. 5.)

Twenty-two days after formation of the tube on the left arm, a flap of skin 4 inches wide and 2 inches long, beginning just below the mandible on the left side of the face, was elevated. The distal end of the tube on the left arm was severed. The tube was then doubled on itself and 2 inches of it unrolled and implanted into the defect on the left side of the face made by elevation of the flap. Interrupted No. 0000 black silk vertical on end mattress sutures were used to approximate the tube to the face.

After implantation of the tube, all but a small portion of the flap of scar on the face was excised. The portion of flap that was allowed to remain was sutured to the edges of the

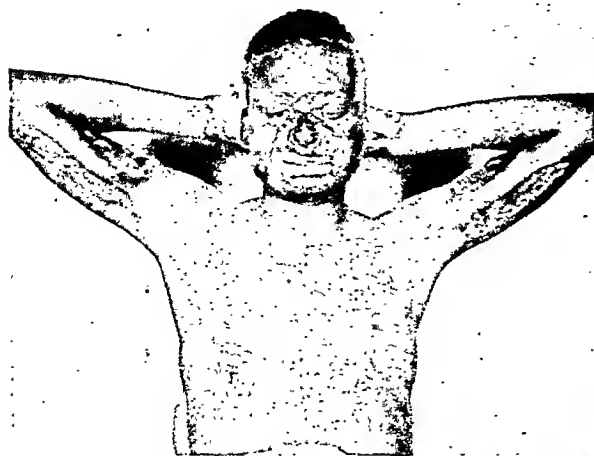


FIG. 5. Bilateral bicipital tubes with skin grafts to arms.



FIG. 6. Distal end of tube migrated to left submaxillary region.

opening in the partially unrolled tube in order to eliminate drainage from the raw surfaces of the latter. Cod liver oil-sulfathiazole gauze and firm pressure dressing were placed over the migrated portion of the tube. The arm was immobilized with the left hand on the right side of the head by gauze bandage and adhesive tape. All sutures were removed on the sixth day after operation and the incision line was found to be well healed. In order to prevent widening of the incision scar, collodion strips were placed along it for support for two weeks. (Fig. 6.)

Thirty-one days after the distal end of the tube had been migrated to the face, the proximal end of the tube was severed from the arm. Although there was active bleeding from the cut end of the tube, it was believed that too great an insult to the blood supply would result if the remainder of the tube was unrolled and implanted. Consequently, only the distal 2 inches were unrolled. After elevation and excision of the scarred skin of the right nasofacial angle, the nose and part of the left cheek the unrolled part of the tube was sutured in place with No. 0000 interrupted black silk. A portion of the scar of the cheek was left as a flap to close the open portion of the tube.

The tube had been severed in the axillary crease of the left arm. This defect was closed with No. 40 cotton interrupted sutures in the subcutaneous tissues and No. 0000 black silk in the skin. The same type of gauze and pressure dressing that was used previously was applied to each of the operative sites. On the fourth day following operation, alternate sutures were removed from the face and the incision was well healed. The remainder of the

sutures were taken out of the face on the sixth postoperative day when all the sutures were excised from the axilla where the edges of the incision were found to be united.

Twelve days later, the distal end of the bicipital tube of the right arm was migrated to the right submandibular region in the same manner as that described for the left side.

It was believed, however, that completely unrolling and implanting the tube would produce a better cosmetic result than that obtained by the method employed in migrating the tube on the left side of the face. In order to do this and still be assured of good circulation in the tube, the blood supply from the proximal end was partially interrupted by incising the skin after twenty-eight days. This procedure resulted in increased and hypertrophied circulation to the tube from the distal end which had been previously migrated to the submandibular region.

Fourteen days afterward, the previously migrated bicipital tube on the right arm was severed at its proximal end and unrolled. Much of the fat was removed from the pedicle flap, then the scarred skin which had produced ectropion of the right upper lip and distortion of the angle of the mouth was excised along with the damaged tissue of the whole right cheek. The pedicle flap was then laid into the defect and sewed in place with No. 0000 interrupted black silk sutures. The upper end of the flap was crowded into the lower medial portion of the right eyelid and was used to correct the small ectropion which had resulted from the partial loss of the eyelid graft. The defect in the right arm was closed in a manner similar to that used on the other arm.

On the fifth postoperative day, alternate sutures were removed and the wound was well healed. The contour of the cheek was found to be very satisfactory. The remainder of the sutures were removed on the following day.

The portion of the pedicle flap on the left side of the face that had remained as a tube was unrolled. After the scar of the cheek that it covered was excised, the flap was implanted into the defect in the same manner as previously described.

After the last operation it was obvious that the left side of the face contained much more fat than the right. Before correcting this, however, formation of a more acceptable nasofacial angle on the left was attempted. A vertical incision was made on the left side in the migrated tube pedicle along the junction of the nose and face. Fat was removed from the edge of the flap on each side of this incision and each skin edge then sewed down to the base of the cheek with No. 40 cotton in the subcutaneous tissues. The incision was then closed with No. 0000 interrupted black silk sutures. Two mattress sutures of No. 00 black silk were placed along the nasal edge of the incision, brought through the septum and tied over a lead button on the right side of the septum. This was a further means of inverting the edge of the incision and producing a nasofacial fold. The skin sutures were all removed on the fourth day after operation and the wound was well healed. On the tenth postoperative day, the mattress sutures were removed and it was believed that some success had been attained.

The superior incision line of the flap on the left side of the face was opened and a large amount of fat was excised from the under surface. The incision was closed in the usual manner. When the sutures were removed on the fourth postoperative day, the wound was well healed and the contour of the left cheek closely approximated that of the right side of the face.

There was no dysfunction of the arms and the grafts over the biceps were soft, pliable and cosmetically acceptable. (Fig. 7.) The tarsorrhaphy uniting the left lids were divided four months after they were constructed but, because of the contraction of the cicatricial tissue as well as the various surgical procedures on the face, the tarsorrhaphy uniting the right lids was not divided for nine months. Vision in each eye was 20/20 uncorrected and ectropia of the lids were not present. (Figs. 3 and 4.)



FIG. 7. Function of arms unimpaired and appearance good.

Desiccation of the cornea with ulceration is no longer likely because of the protection offered by the new lids. The final appearance is satisfactory and the patient states that to him the extensive and prolonged surgery was very worth while.

#### CONCLUSIONS

The results in this case are far superior to those where split-thickness or even full-thickness skin grafts have been employed. When it is necessary to resurface a large area of the face, full-thickness skin with its own circulation-bearing subcutaneous tissue is the most acceptable material. The sites most readily available and most closely resembling the skin of the face are the pectoral and bicapital regions. In females, the latter site is preferable since no damage is done to the breasts.

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# UNUSUAL METASTATIC MANIFESTATIONS OF BREAST CARCINOMA\*

## CUTANEOUS HEMORRHAGIC METASTASIS

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THE breast is the most frequent site for the primary lesion metastasizing to the skin. Cutaneous metastasis from neoplastic lesions in other sites is an infrequent occurrence. Redlich,<sup>12</sup> in a series of 500 cases of carcinoma originating in various sites, found the incidence of skin metastasis to be 0.4 per cent and Buday<sup>3</sup> encountered three instances of cutaneous metastasis in a group of 336 patients with carcinoma in various locations.

The routes by which a neoplasm may invade the integument are direct extension, permeation or embolism through the lymphatics, or embolism through the blood stream. The resulting lesion, usually a subcutaneous nodule, appears in the advanced stages of carcinoma. In mammary carcinoma it occurs predominantly in the skin of the breast, or after mastectomy, as a recurrent lesion in the integument of the chest or upper arm. The nodules are usually asymptomatic, pink or red in color. They vary from a millimeter to several centimeters in diameter, are discrete or confluent and may elevate or infiltrate the overlying epidermis. If the nodules invade the epidermis, they may cause ulcerating or fungating tumors. On occasion, they may form maculopapular, pseudocystic or pseudovesicular epidermal lesions. If the subcutaneous nodules coalesce, they may produce the hard, fixed, nodular surface in the breast integument known as cancer en cuirasse.

The phenomenon variously described as mastitis carcinomatosa (Volkman,<sup>15</sup> Billroth<sup>2</sup>), acute breast cancer (Rodman<sup>13</sup>), inflammatory carcinoma (Lee and Tannen-

baum<sup>8</sup>) and erysipelas carcinomatosum (Kuettner<sup>7</sup>) is caused by cancer cells in the subepithelial vascular spaces secondary to cancer of the breast. This condition is characterized by the presence of a diffuse redness, induration and edema of the breast integument in addition to the mass in the breast. The surface temperature of the involved skin may be elevated. The inflamed skin area may have a definite, well defined, indurated border which advances peripherally as the disease progresses. In one patient observed by us there were patchy red areas, soft to the touch and indistinguishable in consistency from the surrounding, apparently uninvolved, skin. Gentle pressure on the red areas produced a marked blanching. A biopsy revealed subepithelial spaces filled with cancer cells.

Occasionally, the carcinoma cells propagate in the subepithelial spaces in a plane parallel with the epidermis to produce the condition known as carcinoma eburnée (Alibert<sup>1</sup>). In a case described by Schreiner and Volavsek<sup>14</sup> the skin of the lower extremities, abdomen and thorax became indurated, tense and shiny. The histologic finding was the presence of sheets of extravascular carcinoma cells invading these subepidermal regions secondary to a carcinoma of the breast.

Weber<sup>17</sup> and Van Vonn<sup>16</sup> described instances of cutaneous metastatic breast carcinoma in which the lesion had the appearance of dilated surface blood vessels. The histologic picture in these cases was that of subepithelial dilated capillaries engorged with cancer cells some of which had become necrotic. Weber suggested that

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FIG. 1. Case 1. The retraction of the nipple, pig-skin appearance and hemorrhagic vesicular-like lesions are shown in this photograph.

FIG. 2. Case 1. This is a lateral view showing the same features as in the previous figure.

this phenomenon be known as carcinoma erysipelatodes telangiectaticum. A somewhat different cutaneous manifestation of breast cancer, in which the secondary lesion produced the clinical impression of small, discrete vesicles or cysts, was reported by Freeman and Lynch.<sup>5</sup> The vesicles, however, contained no fluid. Microscopic investigation of the vesicles disclosed that they contained masses of adenocarcinomatous cells with areas of central necrosis.

We have encountered in two patients an unusual type of skin manifestation secondary to breast carcinoma in which the lesions resembled hemorrhagic vesicles. A description of these cases follows:

#### CASE REPORTS

**CASE I.** M. Mc., a sixty-three year old white woman, observed a progressive enlargement of the right breast and a retraction of the nipple about a year before she first visited the clinic. During this period there was an intermittent sanguineous discharge from the right nipple. The patient also noticed the appearance of "blood blisters" on the skin of the involved breast.

Examination revealed the right breast to be elevated and the nipple retracted and stuck. In the subareola region there was a 3 by 4 cm. mass to which the overlying skin was attached. The entire skin surface of the right breast, extending upward to the clavicle and lateral-

ward to the posterior axillary line, was covered with a vesicular and nodular eruption. The lesions, which varied from 0.5 to 2 mm. in diameter, were discrete in some areas and confluent in others. The smaller lesions were pink in color but most of them were a deep purple and had a hemorrhagic appearance. (Figs. 1 and 2.) They were firm on palpation.

Aspiration biopsy of the breast mass was reported as carcinoma. Microscopic study of an excisional biopsy of a skin nodule revealed the lesion to consist of subepithelial spaces lined with endothelium and filled with blood and cancer cells which appeared to be adenocarcinoma. (Figs. 3 and 4.) Roentgenographic studies of the chest were negative for evidence of metastasis. The patient later developed extensive metastases to the lumbar spine and pelvis.

**CASE II.** R. S., a fifty-four year old white woman, noticed a mass in the left breast two months before her first visit to the clinic. The mass increased in size and firmness during the two months and in the second month she noticed an eruption on the skin of the involved breast. One week before she came to this clinic, the patient discovered a lump in the left side of her neck.

Examination revealed the left breast to be elevated and one-half again as large as the right. The nipple was retracted and stuck flush with the areola surface; there was some retraction of the areola itself. The lower half of the breast was edematous and had a pigskin appearance. There were some patches of ery-

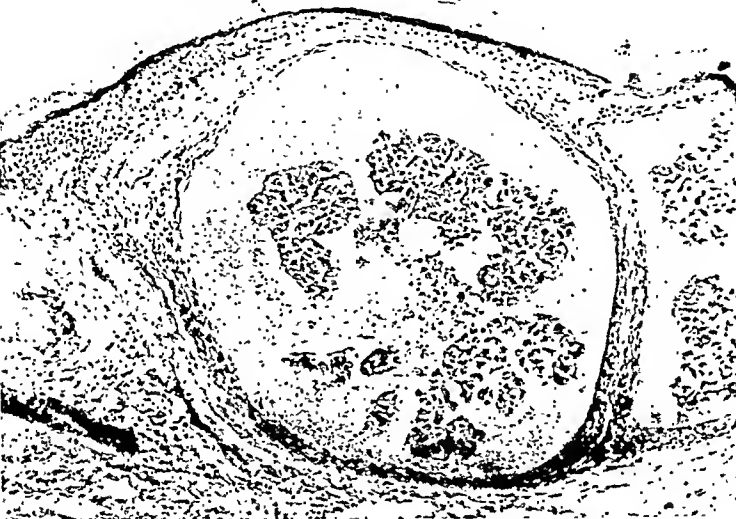


FIG. 3. Case 1. This is a microphotograph of the lesions shown in the previous figures. Two subepithelial spaces lined with endothelium and filled with blood and cancer cells are seen.

FIG. 4. Case 1. This is a higher magnification of one of the subepithelial spaces shown in the previous photograph.

thema in this region. Over the anterior aspect of the breast and involving about one-third of the skin surface there was a large area of pinkish discoloration. In this location, there were numerous, deep purple nodules interspersed with some lighter purple and pink nodules. (Fig. 5.) In some regions, the various groups of nodules were confluent. They extended as isolated lesions as far as the left anterior axillary line. Beneath the pigmented area of the skin and attached to it was an indefinitely outlined mass measuring approximately 8 by 9 cm. In the tail of the same breast, there was obvious dimpling of the skin beneath which another mass measuring 4 by 5 cm. was palpable. This mass appeared to be continuous with a group of nodes extending high up into the left axilla. There was a hard fixed mass of nodes

occupying the entire left supraclavicular space extending up the neck to the region of the mastoid process and anteriorly to the posterior border of the parotid gland. There were several discrete, pink nodules in the skin of the left supraclavicular space.

The mass in the left axilla was aspirated and reported as metastatic mammary carcinoma. A microscopic study of an excised nodule revealed mammary cancer infiltrating the subcutaneous lymphatics. (Figs. 6 and 7.) Radiographic studies of the chest, lumbar spine and pelvis were negative for evidence of metastasis. The patient died of the disease five months after her initial visit to the clinic.

We have been able to find three cases in the literature similar to the ones we are

reporting. Newcomb,<sup>10</sup> in 1924, described a case of breast carcinoma associated with bluish black papules and vesicles in the breast integument. It had the appearance of a melanoma. Histopathologic study of these papules revealed endothelial lined subcutaneous spaces containing cancer cells and blood.

In a case reported by Nix,<sup>11</sup> the patient developed in the skin of the shoulder numerous purplish lesions which appeared to be thrombosed vessels. Clinically, the metastatic lesion resembled a hemolymphangioma. In some areas, the lesion appeared to be composed of discrete cysts but no fluid could be obtained by aspiration. Microscopic examination of this lesion revealed dilated lymphatics and capillaries packed with nests of cancer cells and thrombosed blood.

A similar lesion was described by Nanta and Salvador<sup>9</sup> under the title of cutaneous angio-epitheliomatosis. This consisted of numerous, pink, red, violaceous and black nodules arising from the breast integument in a patient with mammary cancer. In places, the lesion appeared to consist of dilated blood vessels. Histologic investigation disclosed subcutaneous capillaries containing cords of neoplastic cells and masses of erythrocytes. Despite the massive invasion of the capillaries, the lymphatics apparently were not involved.



FIG. 5. Case 11. Retraction of the nipple pig-skin appearance and hemorrhagic vesicular lesions are seen.

#### COMMENT

At times, carcinoma of the breast may be associated with such apparently diverse phenomena described as inflammatory carcinoma, carcinoma eburnée, carcinoma en cuirasse, carcinoma erysipelatodes telangiectaticum, vesicular and hemorrhagic vesicular lesions. All of these phenomena can be explained on the basis of the same underlying mechanism, namely, the occlu-

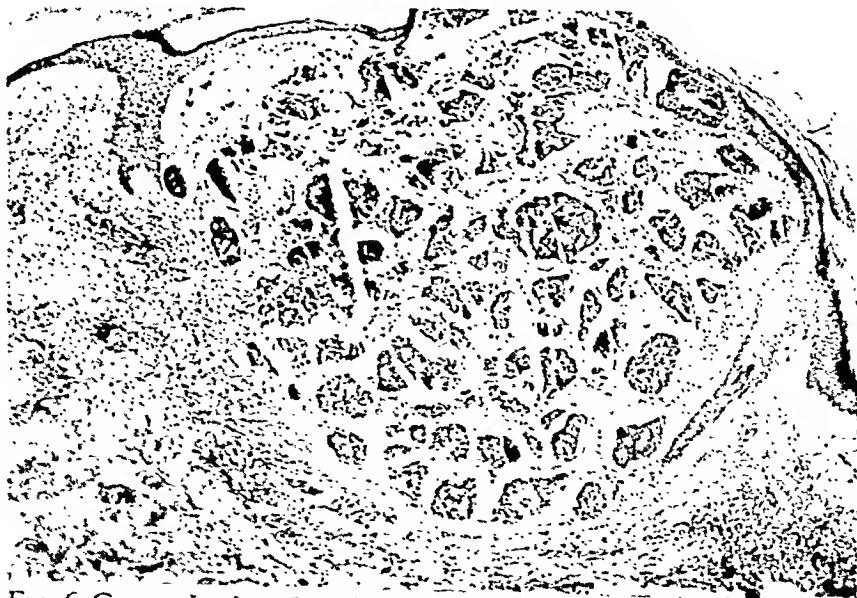


FIG. 6. Case 11. In the subepithelial region a group of dilated endothelial lined spaces filled with masses of cancer cells may be seen.

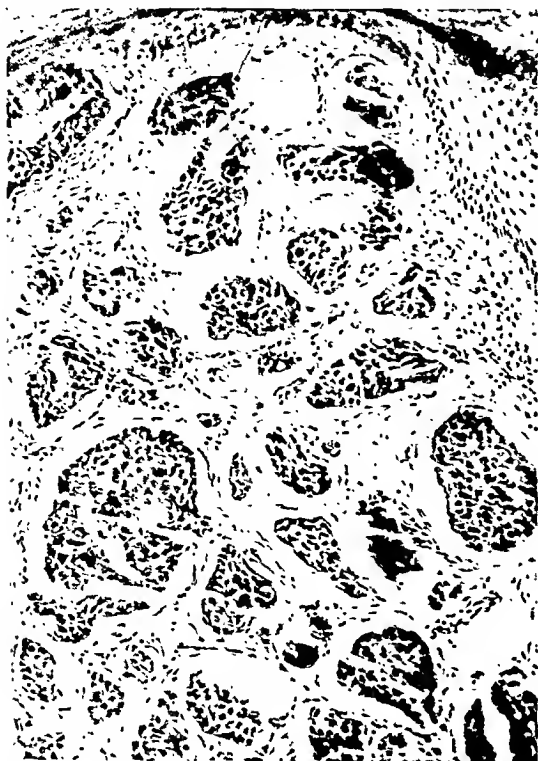


FIG. 7. Case 11. This is a higher magnification of an area shown in the preceding figure.

sion of the subepithelial vascular system with neoplastic cell masses.

In the condition variously described as inflammatory, acute or erysipeloid breast cancer, there is interference with the return flow of lymph from the integument caused by cancer cells in the lymphatic channels. This stasis induces an inflammatory reaction in the adjacent tissues which imparts to the skin the characteristic red color.

In the condition described as carcinoma eburnée, it appears that the cancer cells reach the subepidermal region by permeation through the lymph channels. The neoplastic cells then pass through the walls of the lymph vessels to propagate in the tissue spaces; thus, they form a continuous sheet of cancer cells extending beneath the skin in a plane parallel with it.

The vesicular and cystic lesions probably result from the occlusion and consequent dilatation of the superficial lymphatics by large masses of tumor cells. The cancer cells in the center of the cluster undergo necrosis because of their distance from the surrounding sources of nutrition. This cen-

tral necrosis produces the semblance of a cyst or vesicle.

The telangiectatic and hemorrhagic lesions are probably the result of a mechanism similar to that just described except that the venous capillaries, instead of the lymphatics, are involved. Masses of cancer cells obstruct the capillary return flow. The trapped erythrocytes produce dilatation of the blood channels, with the resultant formation of hemorrhagic vesicles containing cancer cells, or an area of telangiectasis in which the dilated vessels are engorged with cancer and red blood cells. This would explain the gross and microscopic pictures in our first case. In the second case only dilated endothelial lined spaces containing cancer cells were seen on histologic examination. The absence of blood leads one to the conclusion that these are lymphatic channels. Undoubtedly, both lymphatic and venous capillaries were involved in this case but the biopsy was probably taken from a non-pigmented or lymphatic lesion.

The various cutaneous manifestations just described are apparently the result of metastasis from an associated breast carcinoma. We concur with the opinion of Dawson and Shaw<sup>4</sup> that there seems to be little justification for considering these various phenomena associated with mammary carcinoma as distinct pathologic entities. Fischer<sup>6</sup> has proposed the term subepidermoid breast carcinoma to describe this group of cases. We suggest that this group of metastatic phenomena be known by an appellation which acknowledges their common etiology, namely, as metastatic cutaneous manifestations of breast carcinoma.

#### SUMMARY AND CONCLUSIONS

1. The phenomenon of cutaneous metastasis secondary to breast cancer has been briefly described.
2. A number of unusual examples of this manifestation have been collected from the literature.
3. Two cases exhibiting hemorrhagic vesicular-like lesions are reported.

4. A theory is proposed to account for the various cutaneous manifestations discussed.

5. It is suggested that these apparently diverse skin phenomena be grouped under the generic title of metastatic cutaneous manifestations of breast carcinoma.

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*Pain in the chest* may be due to metastasis in the pleura from carcinoma of the uterus, breast, or other organs, pleural effusion or hemothorax may be due to metastasis in the pleura or mediastinum

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# SPONTANEOUS AMPUTATION OF THE FALLOPIAN TUBE

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**T**ORSION of the fallopian tube has come to be recognized as a definite disease entity. Apparently Bland Sutton<sup>10</sup> reported the first surgical case of torsion of the fallopian tube in 1890. Anspach,<sup>2</sup> in 1912, collected data on more than eighty cases of torsion of the fallopian tube, the majority of which were associated with an enlargement of the tube. Since then, rarely a year has passed in which additional cases of torsion of the fallopian tube have not been reported in the literature. In the majority of cases, there have been associated pelvic pathologic findings.

Blum and Sayre<sup>4</sup> stated that Stark in 1911 reported the first case of torsion of the normal adnexa in a virgin. Blum and Sayre listed nineteen cases, reported between 1913 and 1937, as being cases representing torsion of the undiseased fallopian tube in virgins and gave a résumé of data on these cases. They referred to additional cases reported by Stark in 1911, Norris in 1911, Cassidy and Norbury in 1911 and one other by Auvray in 1912 thus making a total of twenty-three cases which they accepted as being torsion of the normal tube.

There is a discrepancy among various authors reviewing this subject as to the total number of cases of normal tubes that have undergone torsion. This is a result of variation in interpretation among authors as to what the pathologic status of the tube was initially, for, as is readily recognized, torsion produces pathologic changes in the tube and it is difficult to establish the true state of the fallopian tube before torsion occurred. Regardless of the lack of agreement, one is forced to the conclusion that torsion of a normal tube has come to be recognized as a definite entity and that it has been observed by a number of writers since 1911 when it was first reported.

The most discussed aspect of the cases of torsion or amputation of the adnexa has been the mechanism of formation of the lesion. This problem has been debated back and forth since as long ago as 1860 when von Rokitansky<sup>9</sup> stated that torsion of the adnexa could be attributed to the presence of an ovarian enlargement, to constriction of the tube by pseudomembranes that result from intrauterine or extra-uterine inflammation or to strangulation of the tubes and ovaries by axial rotation. Other explanations that have been advanced have been reviewed by Blum and Sayre<sup>4</sup> and also by Thorek.<sup>11</sup> They mentioned the hemodynamic hypothesis of Payr based on the fact that veins of the mesosalpinx are longer and more flexible than the arteries thus predisposing to torsion in cases of venous congestion of the mesosalpinx. They noted Sellheim's hypothesis that sudden stoppage of certain movements of the internal organs may induce axial torsion. They mentioned the likelihood of an abnormally mobile mesosalpinx contributing toward torsion especially if associated with other congenital abnormalities. This is called the anatomic hypothesis. They noted the possibility of vulvovaginitis in childhood associated with secondary pelvic inflammatory reactions being another etiologic factor. Other etiologic factors were mentioned as being ovarian cysts, pelvic inflammatory disease and enlargements of the tube.

Thorek stated that torsion occurs three times more frequently on the right than on the left side. He stated that Gabe believed this may be explained because of the presence of the sigmoid on the left side.

In 1943, Barrett and Lash<sup>3</sup> reported a case of spontaneous amputation of the left, normal fallopian tube accompanied by a right ovarian cyst in a forty year old pa-

tient. They referred to Ogórek's<sup>6,7</sup> two cases in which there were associated pelvic pathologic changes. Ogórek<sup>6</sup> reviewed the literature up to 1914; in 1900, Ries<sup>8</sup> reported a thirty-two year old woman who had a normal full term pregnancy and delivery as well as having had two miscarriages. He found the stumps of both tubes and a hematosalpinx in the amputated portion of the right tube but he was unable to identify the remaining portion of the detached left tube. This operation was conducted vaginally. In 1900, Noble<sup>5</sup> reported a spontaneous amputation of the right tube and ovary with parasitic attachment of the ovarian segment to the mesentery in a forty year old Negro woman. A cyst the size of a coconut was removed from the left side of the pelvis. This was reported to have been a cystoma. Barrett and Lash mentioned that cases of spontaneous amputation of the tube had been reported by Kaufmann, Kadygrobow and Pulvirenti.

The only additional case that we have been able to discover in the literature is that of Anderson<sup>1</sup> who reported a case in which the patient was a twelve year old child who was found to have a detached segment of the left tube, the size of a small grapefruit, which was filled with hemorrhagic contents. The proximal stump was 1.5 cm. in length and was sealed over.

We wish to report two cases in which spontaneous amputation of the left fallopian tube occurred.

#### CASE REPORTS

**CASE 1.** The patient was a twenty-eight year old unmarried woman, admitted to the Mayo Clinic on January 11, 1946. She complained of recurrent attacks of pain in the left lower quadrant of the abdomen that had been occurring over a period of the preceding four years. Four years before her admission, she had experienced a sudden onset of severe pain in the left lower quadrant which persisted for forty-eight hours. This pain gradually subsided but left a residual tenderness that was made more noticeable by walking. The following four months she experienced an attack of severe

pain in the left lower quadrant weekly, lasting from four to five hours. At the end of four months an unusually severe attack confined her to bed five days and opiates were required to give her relief from the pain. At no time did an elevation of temperature develop. The frequency of the attacks of pain had subsided during the two years prior to her admission and she had experienced an attack but once a month which confined her to bed twenty-four to thirty-six hours. These attacks were in no way associated with the menstrual cycle. At times she would be awakened in the middle of the night with an onset of acute pain. During these two years the menstrual flow had increased from five to ten days in duration and she noted an increase of the daily menstrual flow. There was no dysmenorrhea and there was no history of a vaginal discharge. She had very definitely observed that vigorous physical activity, such as running and heavy lifting, would precipitate an attack of pain. She gave a history of having had pertussis and mumps as a child. She had not experienced any other illness. Menstrual periods began at the age of fifteen years; they were regular, occurring every twenty-eight days, and were of the normal type.

The patient was 65 inches (165 cm.) tall and weighed 125 pounds (56.7 Kg.). The pulse rate was 92 and the temperature was 98.6°F. The systolic blood pressure was 142 and the diastolic 90 mm. of mercury. A physical examination revealed the patient to be a normal nullipara. The pelvic examination revealed a small cystic mass in the region of the left ovary which was slightly tender to palpation. Urinalysis for albumin, sugar, bacteria and microscopic cellular structures was reported as negative. The concentration of hemoglobin was 14.0 Gm. per 100 cc. of blood. Leukocytes numbered 6,800 per cu. mm. of blood. The Kline test for syphilis gave negative results. A roentgenogram of the thorax was negative. The sedimentation rate was reported to be 8 mm. per hour (Westergren). In view of the attacks of pain and the cystic enlargement in the left adnexa, it was thought advisable to conduct abdominal exploration.

Abdominal exploration was carried out on January 17, 1946, through a low midline incision while the patient was under nitrous oxide, oxygen, carbon dioxide and ether anesthesia. The uterus, the right tube and ovary and the left ovary were normal to examination



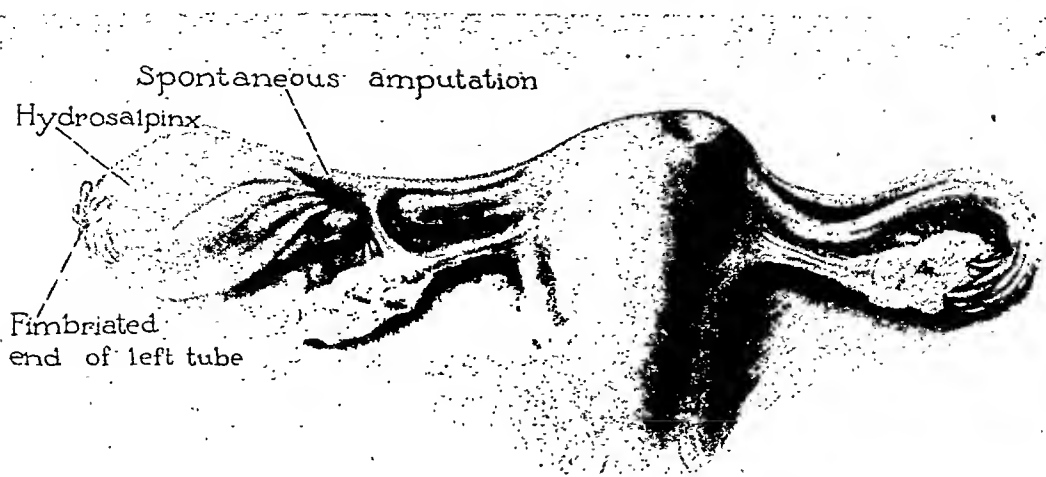


FIG. 1. The condition found at operation: amputated left fallopian tube and associated hydrosalpinx of distal segment.

except for two uterine fibromyomas 1 cm. and 0.5 cm. in diameter which were removed by myomectomy. The left fallopian tube had undergone spontaneous amputation and was found to be in two portions. (Fig. 1.) There was one complete twist of the pedicle of the distal half of the left tube. This segment was found to have the fimbriated end sealed over and a hydrosalpinx 7.5 by 2 by 1.5 cm. had formed. This segment of tube was removed. The left ovary was not involved in any manner. There appeared to be a band of adhesions that had extended across the left side of the pelvis in the region of the amputation. This remained as a thickened peritoneal fold. The proximal half of the fallopian tube had sealed over. We attempted a plastic procedure on the sealed end of this segment of tube by bringing mucous membrane over the muscularis layer. We then inserted a piece of chromic catgut through the lumen of the tube into the uterine cavity with the hope that this would prevent the new ostium of the tube from sealing over. The appendix was removed secondarily and the stump inverted. The abdomen was closed with a layer of single continuous chromic catgut No. 1 in the peritoneum and a layer of double continuous chromic catgut in the fascia.

The pathologist reported a hypertrophic endometrium. The appendix showed chronic catarrhal appendicitis.

The patient was dismissed from the hospital on the thirteenth postoperative day and was allowed to return to her home the twenty-fifth postoperative day with the incision well healed.

CASE II. The patient was a twenty-one year

old unmarried woman, admitted to the clinic March 4, 1922. She complained of severe recurrent attacks of pain in the right lower quadrant of the abdomen that had occurred over a period of twelve months prior to her admission. On three occasions the pain was so severe that the patient collapsed. During the two weeks prior to her admission the pain in the right lower quadrant had recurred and had gradually increased in intensity. She was able to obtain slight relief by flexing the right thigh on the abdomen. She had noted a marked yellow leukorrhea for a period of one year. She gave a history of having had scarlet fever at the age of four years and influenza in 1918. There were no other previous illnesses. Her menstrual periods began at the age of twelve years; they were always irregular, every two to three weeks, and lasted for six or seven days.

The patient weighed 127 pounds (57.6 Kg.), her pulse rate was 110 and her temperature 98.6°F. The systolic blood pressure was 118 and the diastolic 82 mm. of mercury. Her physical examination, other than that related to the abdomen and pelvis, did not give remarkable results. The right lower quadrant of the abdomen was markedly tender and definitely rigid. Pelvic examination revealed a very tender mass in the region of the right adnexa. A roentgenogram of the thorax was negative, the leukocytes numbered 10,300 per cu. mm. of blood and the Wassermann reaction was negative.

On March 9, 1922, Dr. C. H. Mayo explored the abdomen through a low midline incision while the patient was under ether anesthesia.

He stated that the uterus was slightly enlarged and fixed to the right side of the pelvis. There were many adhesions between the sigmoid and the left ovary. The left fallopian tube had undergone spontaneous amputation and the proximal portion of the tube had sealed over forming a blind stump. The fimbriated end was free and open and measured  $1\frac{1}{2}$  inches (3.8 cm.) long. There was no evidence of infection of the tube. The right tube was dilated and showed chronic salpingitis and the fimbriated end was sealed over. The right tube and the appendix were removed. The pathologist reported the right tube to show evidence of chronic salpingitis. The appendix showed chronic appendicitis with obliteration of the tip. The patient was dismissed from the hospital the twelfth post-operative day with the incision well healed.

#### COMMENT

Spontaneous amputation of the fallopian tube may be the result of any one of several etiologic factors. It appears probable that torsion of a segment of a fallopian tube on an unusually long mesosalpinx could frequently be considered an etiologic factor particularly when associated with adnexal pathologic changes and segmental enlargement of the tube. Old inflammatory peritoneal bands that have formed as a result of previous vulvovaginitis, a ruptured appendix or other types of pelvic peritonitis may be the factor involved in another group of cases.

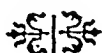
It is difficult to attempt a reconstruction of the exact pathologic processes involved in the two cases presented. In the first case there was hydrosalpinx of the amputated segment. In addition, there was a complete twist of the pedicle of the mesosalpinx associated with a peritoneal band at the site of the amputation. Inasmuch as there

was no evidence of additional pelvic disease, we are inclined to explain the amputation on a basis of torsion. Whether the hydrosalpinx was primary or secondary is a question that must remain unanswered in this case. The second case is an example of amputation of a tube that appeared normal in all respects. The fimbriated end of the amputated segment had remained open; however, there was extensive evidence of pelvic inflammatory disease in the other adnexal structures. An inflammatory band of adhesions may have been the etiologic factor in this case.

Cases of spontaneous amputation of the fallopian tube are gynecologic curiosities and are so unusual that the reporting of these two cases appears justifiable.

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# DYSGERMINOMA OF OVARY\*

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THIS type of tumor may also be described as seminoma or embryonal carcinoma with lymphoid stroma. It is a malignant, radio sensitive, cellular tumor, occurring at rather early ages, lacking hormonal effects, is composed of large polyhedral cells of embryonal type and lies in a loose stroma containing many lymphocytes. The structure and clinical features are probably the most characteristic of any ovarian neoplasm. Pseudohermaphroditism, true hermaphroditism, primary amenorrhea, infantile uterus, ovarian hypoplasia or hirsutism may coexist with this type of tumor. This tumor may also be associated with teratoma or chorioma of the ovary.

A few small tumors have been discovered but the growth is usually rapid and attains considerable or large dimensions before detection. The early tumors are encapsulated and offer a good prognosis; others have infiltrated the capsule and invaded tubes and pelvic peritoneum and in some the disease is widely spread through the pelvis, abdominal lymph nodes, liver, lungs and other organs. The prognosis varies with the extent but most of the unilateral encapsulated growths have failed to recur after operation. The gross section exhibits a solid gray surface often marked by areas of hemorrhage and necrosis.

The structure is very characteristic permitting a positive diagnosis in nearly all cases, an advantage enjoyed by few ovarian tumors. The cells are large, round or polyhedral, granular with large vesicular nuclei lying in stroma which is generally infiltrated with lymphocytes, or the cells are clear, polyhedral lying in large alveoli with stroma containing few lymphocytes or hyaline. Occasionally areas of degeneration

containing giant cells and suggesting tuberculosis have been found.

The treatment of dysgerminoma has generally been surgical and with unilateral, encapsulated tumors the prognosis is good. In all other cases, which constitute the majority, surgery is ineffective. The structure is essentially radio sensitive and should respond in the ovarian tumors as it does in the testicular growths for which radiation has largely replaced surgery.

The origin of the seminoma has been assigned by Meyer to cells derived from the primitive gonad at a very early period and before sex characteristics have been imparted to them by the true sex cells. This assumption is demanded by the absence of sex properties and hormonal effects and by the occurrence of similar tumors in the testes.

## CASE REPORT

On August 14, 1946, a white female of Syrian extraction, aged twenty-seven years, referred by Joseph Ganim, M.D., was admitted to the hospital complaining of abdominal distention, pulling sensation in both flanks, backache and pain radiating to both shoulders. The onset of symptoms began July 28, 1946, and all had increased gradually in intensity. The patient had been married two days prior to onset of symptoms. There was no disturbance in digestion. She was moderately constipated but this symptom was a chronic condition. There were no symptoms referable to the urinary tract. The patient began to menstruate at thirteen years. Her periods were regular, occurring every thirty days and lasting four days. The flow was moderate and without clots. Moderate cramps occurred for four or five hours at the onset of flow. There was no history of vaginal discharge. The patient had the usual childhood diseases and had always enjoyed rather good health.

The patient was one of eight children (two

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boys and six girls), all living and well. Her father had died at fifty-one years of cerebral hemorrhage; the mother, forty-nine years, was living and well.

On physical examination the patient was found to be a well nourished and well developed, slightly obese, white female, with physical findings confined entirely to the abdomen. The latter was uniformly enlarged. The umbilicus was concave. The superficial veins were slightly prominent. No operative scars were present. Dullness was obtained in both flanks. No definite fluid wave could be ascertained. On pelvic examination the cul-de-sac was distended and bulging uniformly. A tumor mass could be palpated on bimanual examination. This mass seemed to be attached to the right adnexa.

On admission the temperature was 98°F., pulse 108, respirations 20, and blood pressure 120/90.

The following laboratory data were reported: Urine, color, cloudy straw; reaction, alkaline; specific gravity, 1.020; negative for albumin, sugar, acetone and diacetic acid. The microscopic showed that the urine was packed with amorphous phosphates. Blood count: red blood cells, 5,070,000; white blood cells, 7,150; hemoglobin, 100 per cent; hemogram, 100 cc., 14.5; polymorphonuclears, 58 per cent; lymphocytes, 27 per cent; large monocytes, 10 per cent; eosinophils, 5 per cent; stabs, 18 per cent; shift, 31 per cent. The Freidman and Kahn tests were negative. On a flat x-ray plate of the abdomen the left kidney and left psoas shadow were visualized. The right kidney and right psoas shadow were not visualized. The bladder was seen and there was no calculus. There was a suggestion of fluid in the abdomen.

On August 21, 1946, an exploratory laparotomy was performed through a mid-line suprapubic incision. On opening the abdomen, approximately 10 liters of serosanguineous fluid was aspirated. The pelvic viscera were examined and a tumor replacing the right ovary was found. This tumor was encapsulated and measured 16 cm. in diameter. There were several rents in the capsule which accounted for the ascitic fluid. The mass had a white appearance and was spongy in character. It was adherent to the left tube and ovary as a result of inflammatory reaction. The right tube and ovary were removed. The uterus, left tube and ovary were normal in appearance and were left *in situ*.

There were several small masses attached to the pelvic peritoneum and were considered transplants. These were also removed by simple excision.

The patient had an uneventful postoperative course and was permitted out of bed on the tenth day, at which time deep x-ray therapy was instituted. The patient will receive during a six- to eight-week period, 4,000 r to the abdomen with equal distribution to anterior and posterior surfaces. The x-ray therapy is given to two fields on the anterior surface and two fields on the posterior surface. The fields measure 10 by 20 cm. The distance is 80 cm. and 200 KV arc used. The filtration is through 1 mm. of aluminum and 1 mm. of copper.

The pathologic report is as follows: Macroscopic: The ovarian tumor and fallopian tube weighed 910 Gm. The fallopian tube measured 12 cm. by 5 mm. and was not remarkable. The cyst measured 16 cm. in diameter and contained a soft, white, spongy tissue. One area 5 mm. in diameter was entirely cystic and contained a clear amber fluid. Microscopic: The fallopian tube showed no significant lesions other than adhesions. The ovarian sections showed a solid tumor of ovary with abundant blood supply and occasional small areas of necrosis. The entire mass was composed of small ovoid and spherical cells of uniform diameter supported by a connective tissue framework in which there were numerous aggregations of very small cells resembling lymphocytes. Mitoses were not infrequent. There was more evidence of growth than is usually present in this type of neoplasm. The dual cell type and other characteristics are typical of dysgerminoma of ovary.

Diagnosis: Dysgerminoma.

The patient was discharged from the hospital on September 11, 1946, and continued x-ray therapy on an out-patient basis.

#### SUMMARY

A case of dysgerminoma of the right ovary is reported in a twenty-seven year old white female, who had been in good health until two weeks before entry into the hospital, with the symptoms of abdominal distention, pulling sensation in both flanks, backache and pain radiating to both shoulders.

# CESAREAN SECTION SEVEN YEARS AFTER HEMIMYSTERECTOMY IN A BICORNATE UTERUS\*

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**E**MBRYOLOGICALLY, in the female the Müllerian ducts become converted into tubes, uterus and vagina below. At the abdominal ostium of the tube, projections develop at an early period and form the fimbriae. If there is failure in the development in a normal manner of the parts just described, it will lead to various abnormalities in the organs of reproduction. There may be aplasia resulting in absence of tubes, uterus or vagina or there may be inhibition in their proper development resulting in the various types of malformed uteri.

Since there are numerous classifications, we will mention the Kaufman modification types. He describes the didelphys or double uteri in which there are two separate tubes, uteri, cervixes and a double vagina. These cases are rarely encountered. The uterus duplex bicornis has the uteri joined externally but there are two distinct uterine cavities. (Fig. 1.) The two cervixes are also joined while the vagina may be double or possess only a septum in the upper portion of the vagina.

The uterus septum shows evidence of deformity by a depression in the fundus; the septum in the uterus may be complete or incomplete. The uterus cordiformis or arcuatus is heart-shaped and the cleft in the upper portion should remind us of a possible intrauterine septum.

The uterus bicornis unicollis (Figs. 2 and 3) develops when fusion is only complete to a point above the cervix. The uterus is usually widely bicornuate with one cervix and one vagina.

Occasionally, we find that one uterine cavity alone communicates with the cervical canal. This condition may not mani-

fest itself at the age of puberty when menstruation is established because menstrual periods may be normal. However, in a period of months the patient will develop pelvic distress due to a hematometria forming in the uterus with the atresia of the cervical canal. The uterus will enlarge and a pelvic tumor will be formed. Because of a large pelvic tumor, a diagnosis of ovarian cyst was made in the first of the two cases that we have encountered. This diagnosis proved incorrect. The patient had a normal vagina and an apparently normal cervix. When the abdomen was opened we found a large tumor which consisted of the right half of a bicornuate uterus with hematometria and a large irregular tube filled with menstium or a hematosalpinx. In this case a total hysterectomy and bilateral salpingectomy was performed. The patient made a normal recovery.

In the case that we wish to present in detail it is important to note that a previous drainage had been established through the rectum and into the left uterine cavity. This was followed by a severe infection with pelvic peritonitis. In searching the literature we were unable to find a case in which a hemihysterectomy had been performed in a uterus bicornis unicollis such as we wish to present. (Fig. 4.) We are reporting the following case because it is unique and it adds another indication to the regular list for cesarean section:

## CASE REPORT

Mrs. C. first came under our observation on January 11, 1935, at which time I saw her in consultation with a rectal specialist. The patient was a female, thirteen years of age. She

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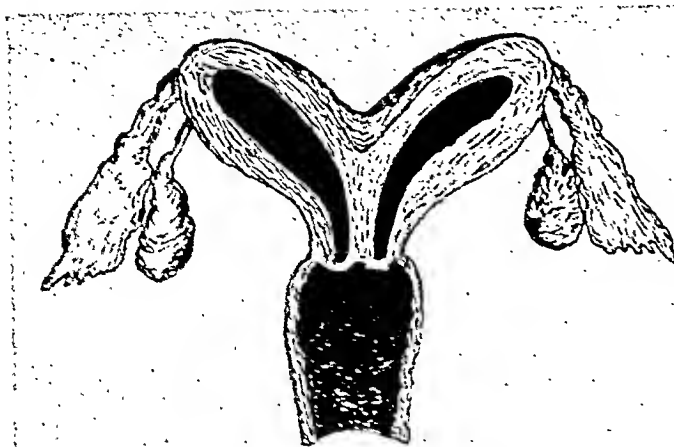


FIG. 1. Uterus duplex bicornis, double uterus; two uterine cavities communicating with vagina via two cervical canals; found in hare, squirrel and beaver.

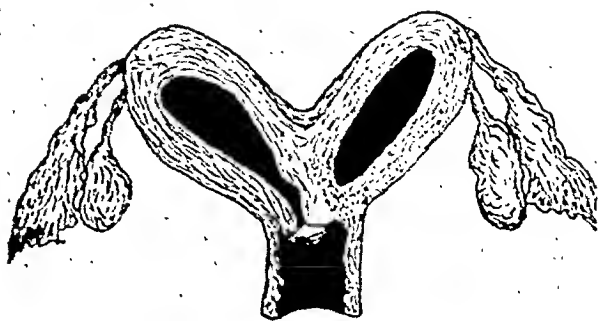


FIG. 2. Uterus bicornis unicollis; drawing shows one uterine cavity communicating with vagina; atresia of left side with no cervical communication; the normal uterus bicornis unicollis is found in the dog, sheep, goat and hyena.

gave a history of having had the usual diseases of childhood but no severe illnesses and no injuries. The onset of her menstruation at the age of twelve years was unusual. It began in September, 1934, and she had only two periods up until we first saw her on January 27, 1935. She stated that in November, 1934, she had difficulty of some kind with her bowels. Constipation was marked and she suffered pain in the rectum when her bowels moved. She apparently improved the bowel condition by using large doses of laxatives. However, on January 9, 1935, the rectal trouble returned and the pain in the rectum became continuous and severe. Her family physician gave her medical care and when she failed to improve, he sent her to White Cross Hospital where she was examined by a rectal specialist. At that time an examination revealed a temperature of  $103^{\circ}\text{F}$ ., a pulse of 120 and respiration rate of 28 per minute.

The erythrocytes were 4,900,000, hemoglobin 95 per cent and the leukocyte count was 16,500 with polymorphonuclears 91 per cent.

The only important finding, as noted by the rectal surgeon, was a large tender mass in the anterior wall of the rectum which was extremely tender to digital examination. Diagnosis of a rectal abscess was made and the patient was taken to surgery. I was called in consultation and upon arrival at the operating table, the rectal surgeon informed me that the patient had a rectal abscess which he

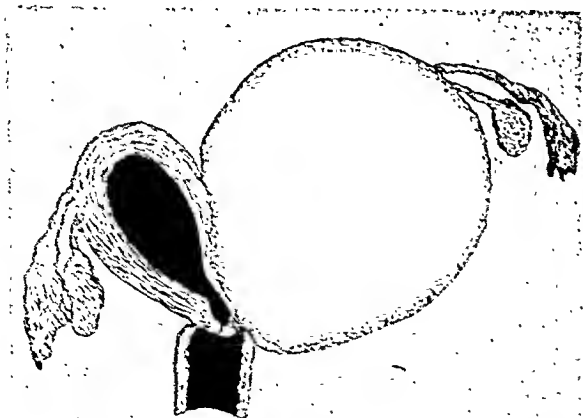


FIG. 3. Uterus bicornis unicollis; same as Figure 2 after puberty, with accumulation of menstrophematometria.

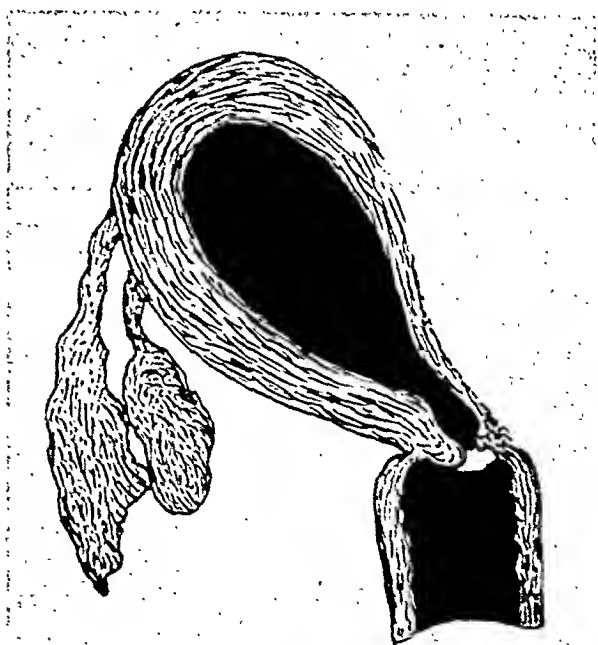


FIG. 4. This shows the remaining right half of the bicornate uterus unicollis after a hemi-hysterectomy had been performed. It was from this remaining uterine body that a fetus was delivered by cesarean section.

wished to incise for drainage and that it would be unnecessary for me to make an examination. He inserted the point of a scissors into the bulging mass which was followed by a gush of dark brownish menstrual fluid. It was a coincidence that we had another patient in the hospital at this same time that had a uterus bicornis unicollis with an atresia of the right cervix resulting in a hematometria, hematosalpinx and hemato-peritoneum. A panhysterectomy had been performed on this patient and my recent observation of the menstruum associated with her abnormality led us to a proper diagnosis, in this case, in the operating room. After noting the fluid gushing from the patient's rectum, we made the diagnosis. The rectal surgeon recognizing the condition present, asked me to assume further care of the patient. The incisional area became infected and the patient was given supportive treatment until January 23rd, when she was permitted to return to her home in order to improve her condition in preparation for abdominal surgery. The patient left the hospital on January 23, 1935. The elevation of temperature was persistent during her hospital stay and it continued until she was readmitted on January 27, 1935, at which time it was 102°F. and the pulse ranged from 100 to 120 per minute. Her erythrocyte count at this time was 3,500,000 and hemoglobin 80 per cent. The leukocyte count was 9,250 with 48 per cent neutrophils, 50 per cent lymphocytes and 2 per cent eosinophils. The urinalysis showed 140 mg. of albumin, leukocytes, erythrocytes and hyalin casts.

The patient was prepared for surgery and an operation was performed for a double uterus with occlusion of the left side, resulting in hematometria. Under nitrous oxide-ether anesthesia, we proceeded with the operation making a paramedian incision. The left half of the uterus with tube and ovary was removed. Drainage was established through the vagina and also through the abdominal incision. Loaded penrose drains were used. The abdominal incision was then closed.

The operative findings were as follows: "Upon opening the abdominal cavity we found a large mass filling the pelvic cavity. This consisted of a uterus bicornis unicollis. The left side comprising most of the mass was swollen, inflammatory and covered by a grayish plastic exudate. It was dark in color upon section and

the cavity had a moderate amount of purulent material with a marked colon odor. The tube and ovary were congested, otherwise not unusual."

Dr. Scott reported the pathologic laboratory findings as follows: "The specimen consists of what apparently is a portion of a uterus; the entire specimen measuring 5 by 4 by 3½ cm. The specimen has been opened before reaching the laboratory and upon further opening the portion corresponding to the endometrial cavity, we find it filled with coagulated hemorrhagic material originating on a basal layer of thin tissue which is not grossly characteristic. Beneath this layer the tissue is characteristically myometrial in type and measures 8 by 10 mm. in thickness.

"Microscopic sections from the specimen show it to be uterine muscle which is somewhat edematous but otherwise not noteworthy. The surface corresponding to the endometrial side is superficially covered with hemorrhagic material, but there is no evidence of endometrium.

"Diagnosis: Accessory uterus."

Following the operation the patient apparently made an uneventful recovery. She left the hospital on February 16, 1935. Her menstrual cycle became established and her periods were regular, every twenty-eight days. Her health improved and she seemed quite well until January, 1942, when she developed an abscess in the left vault of the vagina. She entered the hospital on January 13, 1942. On January 15, 1942, we opened the vaginal abscess and established drainage. The area healed in about three weeks and her health was again normal.

The patient came to my office on June 2, 1942, and told me she had not menstruated for about three months. Pelvic examination revealed an enlarged uterus with softening of the cervix. The Aschheim-Zondek test was positive. Because of her previous pelvic operation she insisted on having an abortion performed because she was afraid of uterine rupture. With some difficulty, we persuaded her to continue with the pregnancy until the fetus would be viable; then the process might be terminated by cesarean section. To this she assented. Again Mrs. C. was admitted to White Cross Hospital on November 11, 1942. After consulting with Dr. W. D. Inglis, Chief of the Obstetrical Staff, a cesarean operation was performed on November 14, 1942.



A right paramedian incision was made and two abdominal sponges were placed around the uterus. The uterus was opened and a male child weighing four and one-half pounds was delivered. The placenta was removed and the uterine cavity was swabbed with iodine. The uterine wall was closed with two continuous sutures of No. 1 chromic catgut. Sulfathiazole (10 Gm.) was dusted over the uterine incision. The right tube was side-stepped for sterilization purposes and the abdomen was closed. The patient made an uneventful recovery and the baby was normal in all respects with the exception of being rather underweight. With careful nursing and incubator care, the child developed in a normal manner. The child is now nearly 5 years of age and is normal physically and mentally. The mother is in excellent health.

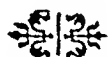
The pregnancy and cesarean section followed after a hemihysterectomy had been performed. Because of the operation, the remaining uterus was abnormal due to the fact that the wall on the left side was thin at the point where the left uterus was

excised from it. At operation the thinness of the left side of the uterus was definitely noted. This patient was not permitted to go into labor because of the danger of rupturing the uterus.

On account of the severe infection and the poor surgical risk, we did not perform a panhysterectomy but removed only the left half of the uterus.

The size of the fetus at birth, which was four and one-half pounds, was obviously due to the lack of circulation to the uterus and placenta. She had only one uterine artery to supply the remaining uterus and fetus. Investigation of double uterus has shown that there is usually an associated widening of the pelvis. However, in this case the patient was normal, weighing 120 pounds and the pelvic measurements are normal.

We advised against pregnancy, but as usual the patient became pregnant soon after marriage.



# HYPERPARATHYROIDISM AND PREGNANCY\*

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**H**YPERPARATHYROIDISM is a well known metabolic disturbance whose various manifestations have been adequately described in numerous reviews.<sup>1,2,3</sup> The occurrence of this disease during pregnancy, however, has been reported but rarely. Spingarn and Geist<sup>4</sup> have described one case and have, in addition, collected six other cases in which the occurrence of hyperparathyroidism and pregnancy may have been concurrent.

The patient of Spingarn and Geist was a twenty-nine year old woman who, at the time of her pregnancy, had had a well authenticated history of hyperparathyroidism for the preceding ten years. During this time, she had undergone one fruitless exploration of her neck and had suffered from numerous spontaneous fractures and renal calculi. At the time of her pregnancy she was described as "thin" and "chronically ill." The authors stated that a second exploration of her neck was considered inadvisable owing to the possibility of precipitating a severe tetany with resultant danger to both mother and fetus. Because of her poor general condition, it was considered necessary to terminate her pregnancy at the fourth month. The fetus was autopsied and was found to have normally developing osseous centers, bone structure and fetal parathyroids.

Two of the other cases reported by Spingarn and Geist are worthy of comment. One<sup>5</sup> was a thirty-two year old Italian woman who survived her tenth, eleventh and twelfth pregnancies while practically bedridden with hyperparathyroidism. The eleventh infant was stillborn but the tenth and twelfth were normal in spite of extensive, incapacitating skeletal changes in the mother. No data were given concerning

abnormalities of calcium metabolism in either of the surviving infants.

A second case<sup>6</sup> involved the occurrence of tetany in a five months old infant whose mother was found to have hyperparathyroidism. It was stated that the mother's hyperparathyroidism had hampered the development of the fetal parathyroids. The infant's hypocalcemia resisted the action of vitamin D and calcium by mouth. In most respects, the baby described resembled other reported cases of tetany of the newborn<sup>7</sup> in which resistance to the action of vitamin D has been noted.

The case history detailed below is thought to be unique in that it reports the successful surgical treatment of hyperparathyroidism in a pregnant woman with subsequent delivery of an apparently normal infant.

## CASE REPORT\*

CASE No. 34455. A twenty-three year old nullipara entered the hospital on May 9, 1945, complaining of the recent enlargement of a mass that had been present on her chin for the past five and one-half months. This mass had been noticed first as a small, non-painful, hard lump, which had remained stationary in size until one month before her present admission, at which time it enlarged rapidly and painlessly.

Her past history revealed that she had been aware of a small lump in her neck for the past four years and had at one time taken "iodine drops" because of this lump. There were no other relevant data other than the fact that her last menstrual period was in December, 1944.

The patient appeared alert and in good health. The blood pressure was 126 mm. mercury systolic and 76 mm. mercury diastolic. There was a hard, non-tender, bulbous swelling

\* The authors wish to express their appreciation to Majors John S. Bagwell, Ridings E. Lee and Captain L. P. Matthei, MC, AUS who saw this patient.

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at the point of her chin. (Fig. 1.) Along the left anterior side of the neck above the suprasternal notch was a firm nodule about 2.5 cm. by 2.5 cm. that moved with swallowing. There was a firm, smooth, rounded mass in the lower central abdomen; pelvic examination revealed changes compatible with a gestation of five months' duration. There was no other physical findings of importance.

The red blood count was 4,280,000; the white blood count 10,700 cells per c. mm. with 74 per cent polymorphonuclear leukocytes and 26 per cent lymphocytes. A Kahn blood test was negative. The urine contained a trace of protein. Repeated examinations failed to detect Bence-Jones protein.

The serum calcium was 19 mg. per cent, the serum inorganic phosphorus 3 mg. per cent and the serum alkaline phosphatase 4 modified Bodansky units. The serum proteins were 7 Gm. per cent and non-protein nitrogen 29 mg. per cent.

When the patient was placed on a calculated daily intake of 100 mg. of calcium and 500 mg. of phosphorus, daily studies of urinary excretion of calcium revealed a negative calcium balance. (Table 1).

Roentgenograms of the kidney region demonstrated collections of calcium granules in each kidney area. Intravenous pyelograms revealed a very poor concentration of dye in the parenchyma of the kidney. The collections of calcium were described as being in the interstitial part of the kidneys and were considered identical with those described in cases of nephrocalcinosis. A faintly calcified fetal skeleton was seen in the abdomen. (Fig. 4.) The degree of fetal calcification was thought to be normal for the period of gestation.

Because of x-ray evidence of calcification of the parenchymal tissue of her kidneys and the possibility of impaired renal function, careful consideration was given to the advisability of terminating her pregnancy. However, in consideration of her normal serum non-protein nitrogen and of the fact that this was her first pregnancy and that conditions were ideal for careful and frequent observation, it was decided to permit the pregnancy to continue and to undertake surgical exploration of her neck.

Accordingly, on June 6, 1945, under local procaine anesthesia, supplemented by nitrous oxide-oxygen, the parathyroid areas were explored. A large mass, corresponding to the

TABLE 1

	May 25	May 26	May 27	May 28	May 29	May 30
Serum Calcium.....	.....	.....	.....	18.75 mg. %	19 mg. %	18.1 mg. %
Serum Phosphorus.....	.....	.....	.....	2.9 mg. %	3.0 mg. %	2.94 mg. %
24 hr Urine Calcium.....	385 as CaO or 276 mg. AS Ca+++	456 as CaO or 325 mg. AS Ca+++	442 as CaO or 315 mg. AS Ca+++	480 as CaO or 342 mg. AS Ca+++	448 as CaO or 320 mg. AS Ca+++	250 as CaO or 178 mg. AS Ca+++
24 hr Calcium Intake in mg.	100	100	100	100	100	100
Ca+++ Balance in mg. ....	-176	-225	-215	-242	-220	-78

Roentgenograms of the chin showed a faintly calcified soft tissue tumor that arose from a discrete area of bone destruction in the mandible slightly to the left of the mental symphysis. (Fig. 2.) Roentgenograms of other principal bones of the body demonstrated multiple destructive lesions associated with generalized decalcification of the skeleton. The destructive lesions involved the left tibia, right sacrum, right ilium, right pubic bone, right ulna, left radius, left patella (Fig. 3) and the left maxilla in addition to the previously described lesion of the mandible.

tumor that had been palpable in her neck for the past four years, was readily located in the tracheo-esophageal groove on the left side just below the inferior thyroid artery. This mass which measured approximately 2.5 cm. by 3.5 cm. was encapsulated, discrete and readily removed. The tumor weighed 13 Gm. Additional exploration, including digital palpation of the superior mediastinal area, uncovered no further abnormal tissue masses. A biopsy specimen was removed from the chin and the operative sites were closed.

Histologic study of the tissues removed was



FIG. 1. Photograph of patient showing distortion of chin caused by the osteoclastoma.



FIG. 2. X-ray study of mandibular tumor, demonstrating bone destruction and a large, faintly calcified soft tissue mass.



FIG. 3. X-ray study showing extensive cystic destruction of left patella.

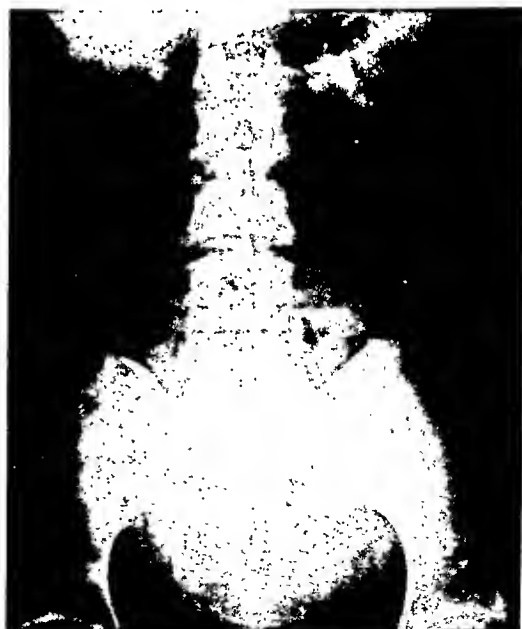


FIG. 4. Roentgenogram of abdomen showing the fetal skeleton, bilateral renal calcifications and destructive lesions of the right ilium.

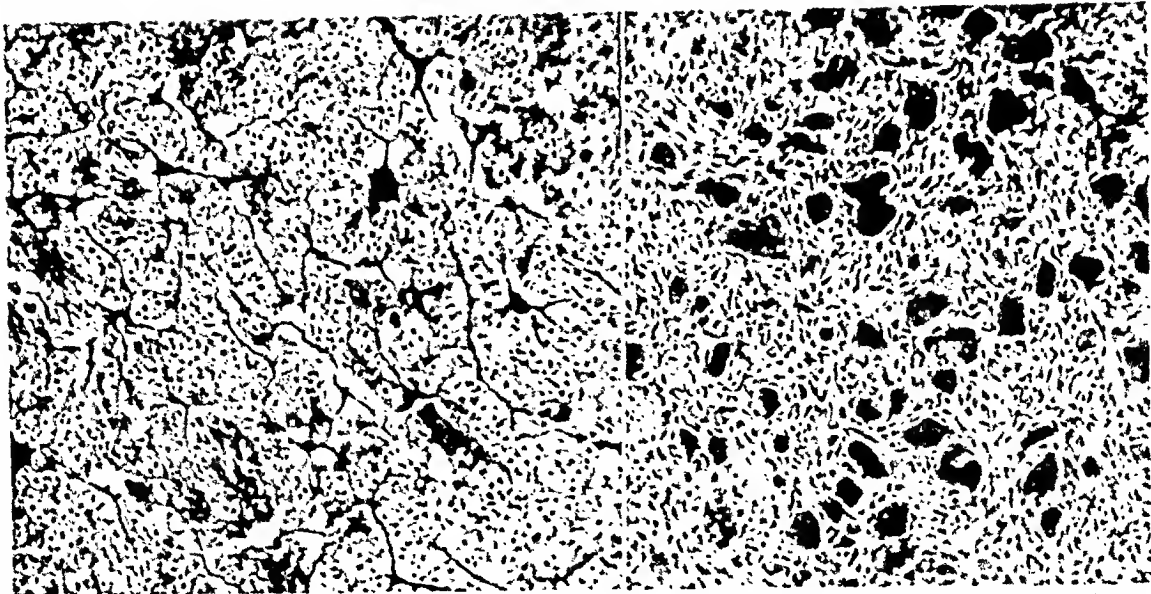


FIG. 5. Microphotograph of parathyroid adenoma.  $\times 100$ .

FIG. 6. Microphotograph of biopsy from mandibular tumor showing large numbers of giant cells.  $\times 100$ .

made by Major George M. Hass, M.C., whose conclusions regarding the mass removed from the neck were as follows: "The structure is essentially that of a parathyroid adenoma. It may be assumed that the patient has hyperparathyroidism. . . . No local recurrence is to be expected and with a tumor of this size, it is

unlikely that there is a generalized hyperplasia of all parathyroid glands." (Fig. 5.) His conclusions regarding the biopsy of the chin were: "The tissue is composed principally of rapidly growing fibroblasts which have deposited very little collagen and which surround large numbers of multinucleated giant

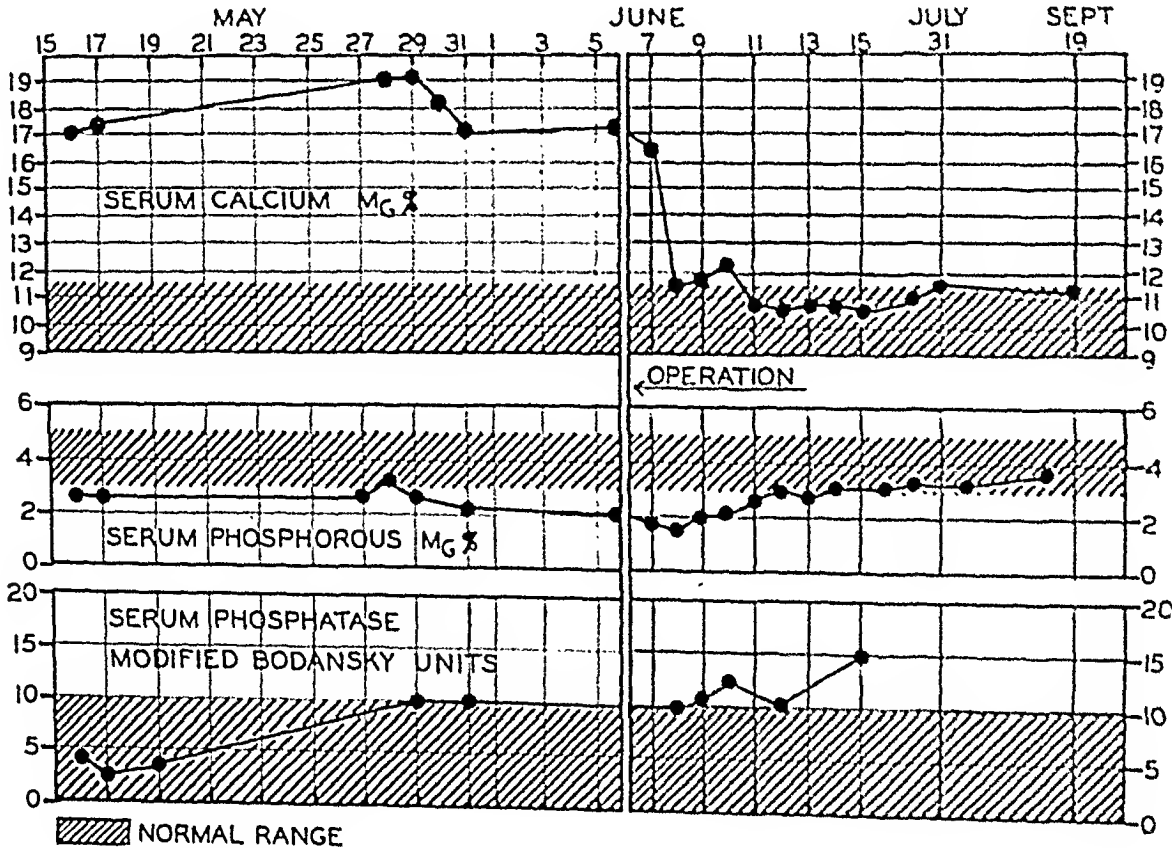


FIG. 7.

cells. There are a few small islands of osteoid tissue with evidence of formation of new bone. . . . This tumor, therefore, has the essential characteristics of a rapidly growing giant-cell tumor of bone." (Fig. 6.)

Calcium, phosphorus and phosphatase concentrations of her blood, determined at frequent intervals, revealed a rapid postoperative drop in the level of blood calcium. (Fig. 7.) Roentgenograms taken August 25, 1945, showed almost complete calcification of the soft tissue tumor of the chin and extensive recalcification of the skeleton. Cystic changes which had been prominent in the right ilium and superior ramus of the right pubic bone were largely recalcified.

The patient completed her period of gestation without further mishap and on September 15, 1945, after an uneventful, spontaneous labor, gave birth to a normal female infant weighing 7 pounds  $5\frac{3}{4}$  ounces. Roentgenograms of the baby's skeleton demonstrated no bony abnormalities. The serum calcium of the infant three days after birth was 10 mg. per cent.

The post partum period of recovery was uneventful. Directly prior to discharge, the serum calcium of the mother was 11.7 mg. per cent, the serum phosphorus 3.3 mg. per cent and the non-protein nitrogen 31 mg. per cent. At this time the tumor of the chin had not receded. Suggestions for further treatment were declined.

#### COMMENT

The principal interest in this case is the simultaneous occurrence of two conditions, each capable of producing profound alterations in calcium and phosphorus metabolism. Pregnancy in the human is associated with normal serum phosphorus, slightly elevated serum alkaline phosphatase and depressed serum calcium levels.<sup>8,9</sup> Hyperparathyroidism is characterized by an increased urinary excretion of calcium and phosphorus by hypophosphatemia, hypercalcemia and, if there is skeletal involvement, by a marked increase in the serum alkaline phosphatase.<sup>1</sup> The signs and symptoms of the disease derive principally from the large daily loss of calcium with resultant decalcification of the skeleton. The decalcification is not confined to

one or two bones although discrete radio-lucent areas, which represent cysts of the giant cell type, may be seen frequently. In addition, the combination of hypercalcemia and hypercalcuria can often result in the deposition of calcium either in the renal pelvis or renal parenchyma. Accordingly, renal calculi may be the first sign of hyperparathyroidism.

Of particular note in this case were the values for normal and near normal serum alkaline phosphatase repeatedly determined by two independent laboratories during both the preoperative and postoperative states. Hyperparathyroidism with normal serum alkaline phosphatase has been noted in certain varieties of this disease. Thus, patients with little or no involvement of the skeleton have no derangement of alkaline phosphatase; furthermore, hyperparathyroid patients whose skeletal changes are those of osteoporosis rather than hyperparathyroidism may have a normal phosphatase level;<sup>1</sup> and, finally, hyperparathyroidism with multiple bone cysts but without generalized decalcification has been seen accompanied by normal phosphatase levels.<sup>3</sup>

Inasmuch as the exact mechanism for the production of an increased phosphatase level is not known, it is difficult to assign a correct explanation for the normal values observed in this case. However, a smooth postoperative course with freedom from tetany has been described before in cases of hyperparathyroidism with normal serum phosphatase<sup>2</sup> and the evidence here is further corroboration of that. Apparently, the surgeon need not be as fearful of acute tetany postoperatively if the preoperative values for serum alkaline phosphatase are normal.

The possibility arises that this patient was protected from postoperative tetany by her fetus. This does not seem likely since it has been shown that parathyroid extract does not pass through the placenta<sup>11</sup> and that parathyroidectomized pregnant rats are not protected from tetany by their fetuses.<sup>8,12</sup>

The renal complications of hyperparathyroidism are of two principal types: the formation of calculi and the deposition of peritubular calcium with calcium metastases in the kidney parenchyma.<sup>13,14</sup> This patient suffered from the latter type. This has been named nephrocalcinosis and, although such renal changes have been observed in certain types of pyelonephritis,<sup>15</sup> its usual cause is the prolonged hypercalcemia found in hyperparathyroidism.<sup>16</sup> The renal deposition of calcium, unlike the skeletal decalcification, is an irreversible process and removal of the parathyroid adenoma is not followed by removal of the calcium from the kidney tissues. Accordingly, although the condition of hyperparathyroidism may be treated successfully by surgery, the course of the patient may progress to eventual renal failure.<sup>13</sup> Although this particular patient did not show signs of renal failure, she was strongly advised against further pregnancies until her kidney function could be again evaluated.

It is interesting to speculate on the possible effect of pregnancy upon this patient's parathyroid adenoma. Inasmuch as it has been shown that the parathyroids enlarge in rats during pregnancy,<sup>17</sup> could it be possible that the tumor found here was activated, after four years of quiescence, at the time of pregnancy? If this assumption is made, it follows that the skeletal changes and renal calcification occurred after conception and during the six months before her operation. Such a rapid course would be unusual since the skeletal changes of hyperparathyroidism are generally considered to be a fairly late manifestation of the disease. Furthermore, this patient had consumed approximately a quart of milk daily during her life which would tend to delay even more the decalcification of her skeleton. In addition, even though microscopic nephrocalcinosis has been seen in acute, short-term, parathyroid poisoning, such interstitial calcification has not been demonstrable by x-ray;<sup>18</sup> the degree of renal calcification

seen in this patient probably required a long-standing hypercalcemia. For these reasons we believe that her adenoma was active prior to her pregnancy and that only the occurrence of the osteoclastoma of her mandible lead to the diagnosis at this time.

In a case such as this, the principal concern of the physician should be with the mother, since the reports previously mentioned<sup>5,6</sup> indicate that the fetus survives the mother's metabolic disturbances with relatively little, if any, change from the normal.

#### SUMMARY

The case of a twenty-three year old pregnant woman suffering from hyperparathyroidism is presented. A large parathyroid adenoma was successfully removed during the fifth month of her pregnancy and she delivered, at term, a normal female child.

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LUPUS of the larynx attacks most frequently the free margin of the epiglottis. Occasionally the entire epiglottis is destroyed without having caused pain or discomfort. This is not the case when destruction results from the ulceration and necrosis of active tuberculosis.

From "Tuberculosis of the Ear, Nose, and Throat" by Mervin C. Myerson (Charles C. Thomas).

# INTRA-ABDOMINAL HEMORRHAGE DURING PREGNANCY

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THE loss of blood intra-abdominally during pregnancy is fortunately rare and Marchetti, Kuder and Kuder<sup>1</sup> report that even the commonest cause, ectopic pregnancy, occurs only once in every 293 pregnancies. Bleeding from uterine rupture, rupture of a vessel on a uterine fibromyoma, ovarian abnormalities, trauma, rupture of a varicose vein, genital and other malignancies during a pregnancy then become even less usual but nevertheless fully as dangerous to the pregnant woman.

The diagnosis of intra-abdominal hemorrhage during pregnancy presents many obstacles to the obstetrician. The bleeding is heralded by sudden abdominal pains followed by symptoms and signs of shock. There is little time for debate and speculation as the potential danger of severe sudden blood loss and resultant death make the diagnosis imperative and immediate treatment cardinal. Fatalities from ectopic pregnancy, for instance, are reported by Williams and Corbit<sup>2</sup> as responsible for one in every eighteen puerperal deaths in Philadelphia, one in every sixteenth death in New York City and one in every twelve deaths in Chicago.

In this report, we are concerned with rupture of a varicose vein during pregnancy as a cause for intra-abdominal hemorrhage. Harding and Concavan<sup>3</sup> reviewed the literature and found twelve such cases. Seven of the cases were discovered at autopsy and there were six survivors including their reported case. In their case they believed the rupture was due in part to sexual intercourse which occurred several hours before admission. All of those reported had as a symptom severe abdominal pain and signs of rapidly advancing shock. At operation the source of bleeding was usually difficult

to locate and almost unrecognized in one incident. Treatment varied from classical cesarean section with ligation of the bleeding vessel, section hysterectomy, to simple ligation. The following is a case report of one of these unusual problems:

## CASE REPORT

Mrs. H. C., a thirty-one year old para 1-0-1, had her last menstrual period July 20, 1945, followed by slight nausea. Her only other pregnancy resulted in a full term normal delivery five years previously. With her first office visit November 20, 1945, the uterus measured 16.5 cm. above the symphysis pubis with the fetus in L. O. A. position; the fetal heart rate was 160 in the left lower quadrant. Her blood pressure was 110/80, urinalysis negative and hemoglobin 85 per cent. She had had an appendectomy performed three years previously and had only one small varicose vein in the right leg.

On December 10, 1945, after a morning of Christmas shopping, she returned home and rather suddenly felt cold, weak and faint. This was followed by dizziness and severe cramps in the lower abdomen and lower mid-back. She was rushed to the hospital by ambulance in a semi-comatose condition and was first seen thirty minutes after her complaints. She had had sexual intercourse four days before her illness.

On admission she complained severely of lower abdominal cramps and was in shock. Examination showed a well developed and well nourished woman who was dyspneic, cyanotic and in acute distress. Blood pressure readings were inaccurate but were approximately 60/38 and the radial pulse was not palpable. Dr. Floyd Burg, medical consultant, declared the heart and chest free of organic lesions. On abdominal examination the uterine fundus could be felt about 20 cm. above the symphysis and there was generalized severe abdominal and flank tenderness. Pelvic and rectal examinations revealed no masses or localized areas of

tenderness. The diagnosis was five months' pregnancy and acute intra-abdominal hemorrhage—cause unknown.

She was immediately given 2 units of plasma (250 cc. each) while she was prepared for surgery. Two 500 cc. transfusions of whole blood were given before and two 500 cc. transfusions of whole blood were given during surgery. The anesthesia included low concentration of cyclopropane and 3 cc. curare. Through a lower left midline incision large fresh clots and free blood were found generally throughout the abdomen and all of the peritoneal surfaces were pale and yellow. There was a five months' intra-uterine pregnancy. A bleeder was found at the base of the posterior right broad ligament which was an irregular longitudinal break in a varicose vein measuring about 4 mm. in transverse diameter. The back bleeding from this rent rapidly filled the cul-de-sac. The total measured volume of blood removed manually and by aspiration was 2,200 cc. not including that on sponges, packs and that left in the abdomen. The fragmented vein was clamped and sutured with No. 1 chromic figure-of-eight suture and bleeding was controlled. Rapid closure was done with No. 0 chromic continuous on the peritoneum and No. 1 chromic continuous on fascia and fine dermal to the skin. She remained in shock throughout the operation despite blood, coramine and ephedrine sulfate.

On her return to bed, the blood pressure gradually rose from 85/0 to 100/50 and her general condition became better. The day following her operation she spontaneously passed a premature non-viable fetus and placenta without difficulty. She remained febrile for three days after the operation and the remainder of her eleven days in the hospital were uneventful. The wound healed *per primum*. She received her fifth transfusion on the second postoperative day. Her essential laboratory work was within usual limits except for evidences of secondary anemia.

Five postoperative examinations between January 3, 1946, and March 5, 1946, revealed a well healed and well supported abdominal wound. The uterus was situated in the anterior position and no unusual masses could be found.

Her hemoglobin with her last visit was 14.5 Gm. (100 per cent).

In the matter of surgical management of this type of hemorrhage from a varicose vein, I favor simple ligation of the bleeding vessel. Perhaps the best argument for this simple ligation is that this procedure is the easiest and quickest possible solution for these shocked women. Emptying of the uterus or a hysterectomy surely adds more shock to an already grave situation by prolonging the anesthesia time and generally increasing the operative burden to the patient. The postoperative vaginal delivery of a premature infant in this report cause no complications but I am quite certain that a section at the surgery table would have jeopardized the patient unreasonably. Further, by simple ligation it might be possible to allow pregnancy to progress to an age when a viable birth would be possible.

The second most important factor in the management of these intra-abdominal hemorrhages in the pregnant is the prompt and complete replacement of the blood loss by blood transfusions. Ideally, the cross-matchings should be proper and the blood should be RH negative. In dire emergency, however, blood plasma and group O blood without crossmatching can be used if the risks of the latter are accepted.

#### SUMMARY

An unusual case of spontaneous rupture of a varicose vein during pregnancy is noted along with previously reported cases and the treatments.

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# PLACENTA ACCRETA

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TRUE placenta accreta is so rarely encountered that its existence is not recognized until some serious obstetrical accident occurs leading to castastrophe. For this reason we believe that the following case merits reporting in the present day literature.

## CASE REPORT

M. M., a colored female aged twenty-nine and para 111, was admitted to the service of Dr. I. R. Hansen with the history of having a premature seven months' delivery at home twenty-four hours previously; she had been delivered by a midwife. The child survived only three hours. The midwife had been unable to express the placenta and, after consultation with Dr. Robert Johnson of the Worcester County Health Department, she was sent to the Peninsula General Hospital on January 21, 1946. No vaginal bleeding had occurred since delivery.

The patient's previous history was that of two past pregnancies. The first was complicated by a placenta praevia and the second by a retained placenta for which manual removal was necessary at another hospital. This occurred in 1942. The course of the present pregnancy had been uneventful except for early labor. Blood Wassermann reaction was repeatedly negative.

One hour after admission, the patient was anesthetized with cyclopropane and oxygen and an attempt made to express the placenta by Crede's method. This failed to dislodge the placenta and caused no vaginal bleeding. Sulfadiazine was administered with pitocin and an ampule of syntropan, none of which produced any result. Conservative treatment was continued for another forty-eight hours, the true condition still unrecognized.

At the end of this period, a dilatation and curettage was attempted by one of us (R. L. R.) under sterile technic and intravenous pentothal sodium anesthesia. The operation report was as follows:

"Routine preparation. The anterior lip of cervix is grasped with tenaculum and drawn down. The cervix is gently dilated, there is a slight cervical tear from the delivery. The large placental forceps is introduced and the placenta which is located in the anterior fundus is grasped. It is impossible to pull it free. It comes free only in small necrotic pieces which are not otherwise abnormal. Attempted curettage is also impossible as the curette will not take off the tissue from the fundus although the rest of the uterus seems normal. A pack was introduced into the uterus and one in the vagina." Some free bleeding occurred at the end of this procedure and the packs were therefore employed.

The senior authors were now consulted and the true diagnosis made. The patient had a violent temperature elevation after the above procedure, the mouth temperature rising to 104°F. This subsided to normal and twenty-four hours later the packs were removed and a supra-vaginal hysterectomy was performed by one of us (L. A. R.). This operation was attended with considerable hemorrhage necessitating two blood transfusions and blood plasma. Four Gm. of sulfanilamide crystals were placed in the lower pelvis. Two Mikulicz's drains were placed in Douglas' cul-de-sac and the abdominal wound closed in layers using buried, stainless steel wire in the fascia.

The postoperative course was uneventful. Penicillin and sulfadiazine were administered prophylactically but the patient had no elevation of temperature, pulse and respiration and was discharged on the twelfth postoperative day with the wound healing well.

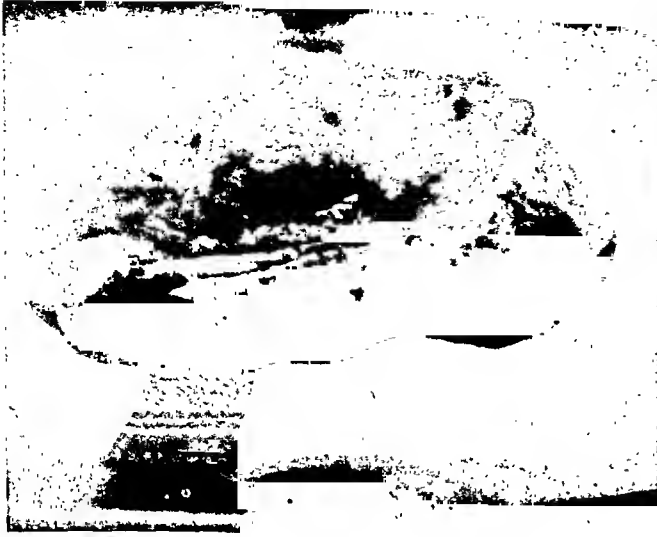


FIG. 1. Lateral view of gross specimen.



FIG. 2. Anterior view of gross specimen.

The pathologic specimen showed a whole placenta densely adherent to the anterior wall of the uterus. The lowermost part showed some necrosis and blood clot from the trauma of the previous day. The remainder of the placenta showed no necrosis and could not be separated. (Figs. 1 and 2.)

The microscopic sections (Figs. 3 to 8) are extremely interesting. The examination and report were made by Dr. Howard Maldies, of Baltimore, and photomicrographs illustrate this report as follows: (1) Sections through the

decidua vera show no definite scarring; however, necrotic changes are present; (2) Other blocks show acute inflammatory changes between the villi as well as an acute metritis; (3) Section of the elevated, whitish, soft area in the lower portion of the cavity, which look like a possible fibromyoma, shows placental tissue; (4) Other blocks show nothing remarkable.

The villi are embedded in the muscle (hematoxylin and eosin stain). They are distorted and small, being replaced by fibromyomatous tissue. Hyaline changes are evident. In the upper region, the villi are clear and well defined.

Van Gieson's stain brings out the connective tissue and the hyaline changes. The intervillous spaces contain blood and a variety of white cells. The stain clearly depicts the excess amount of collagen fibers and also the hyaline changes. This is not shown in the photomicrographs.

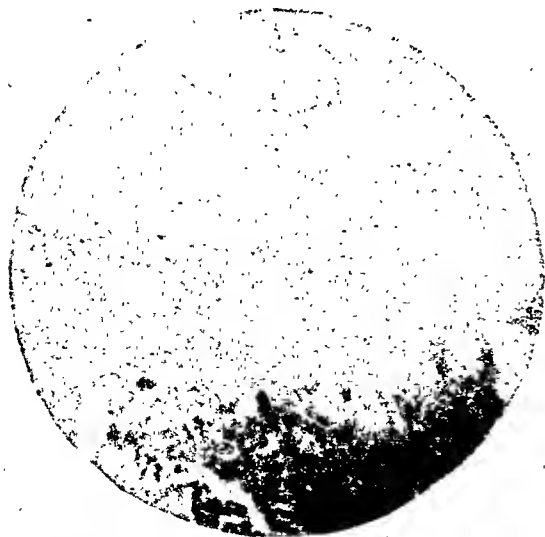
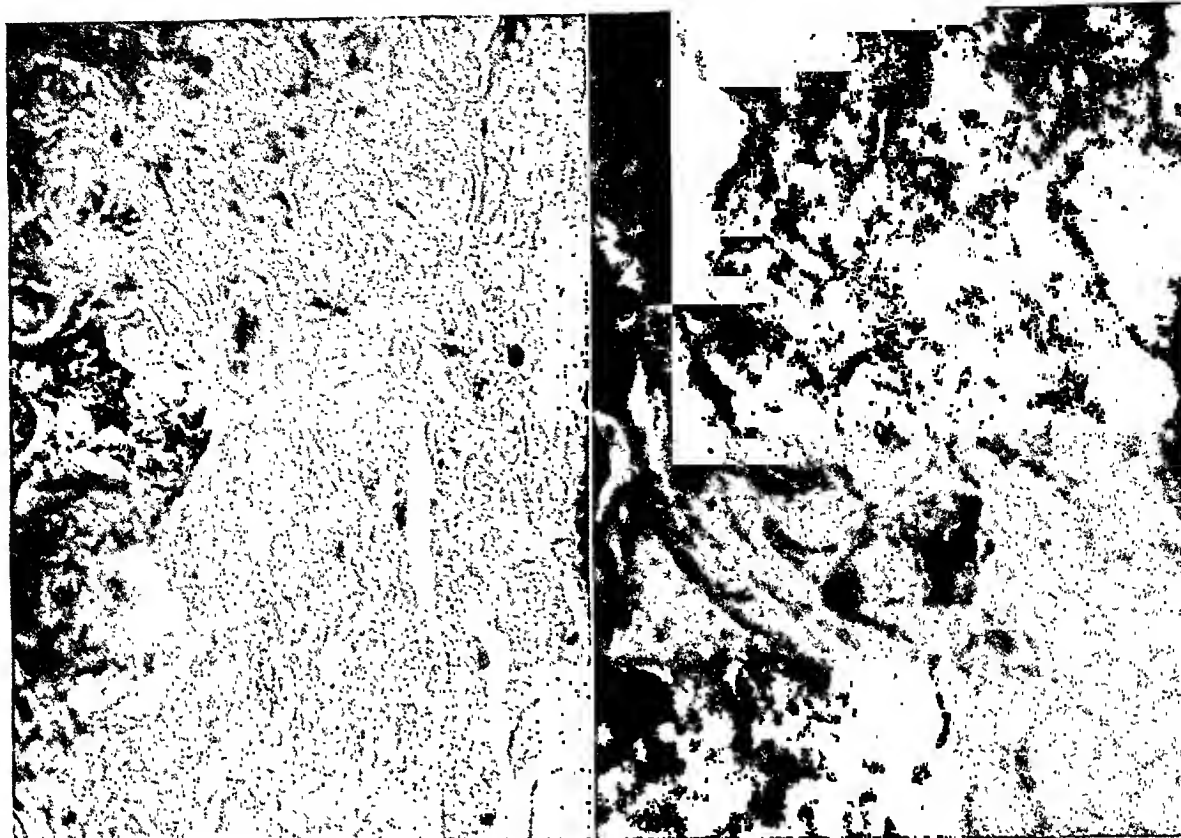
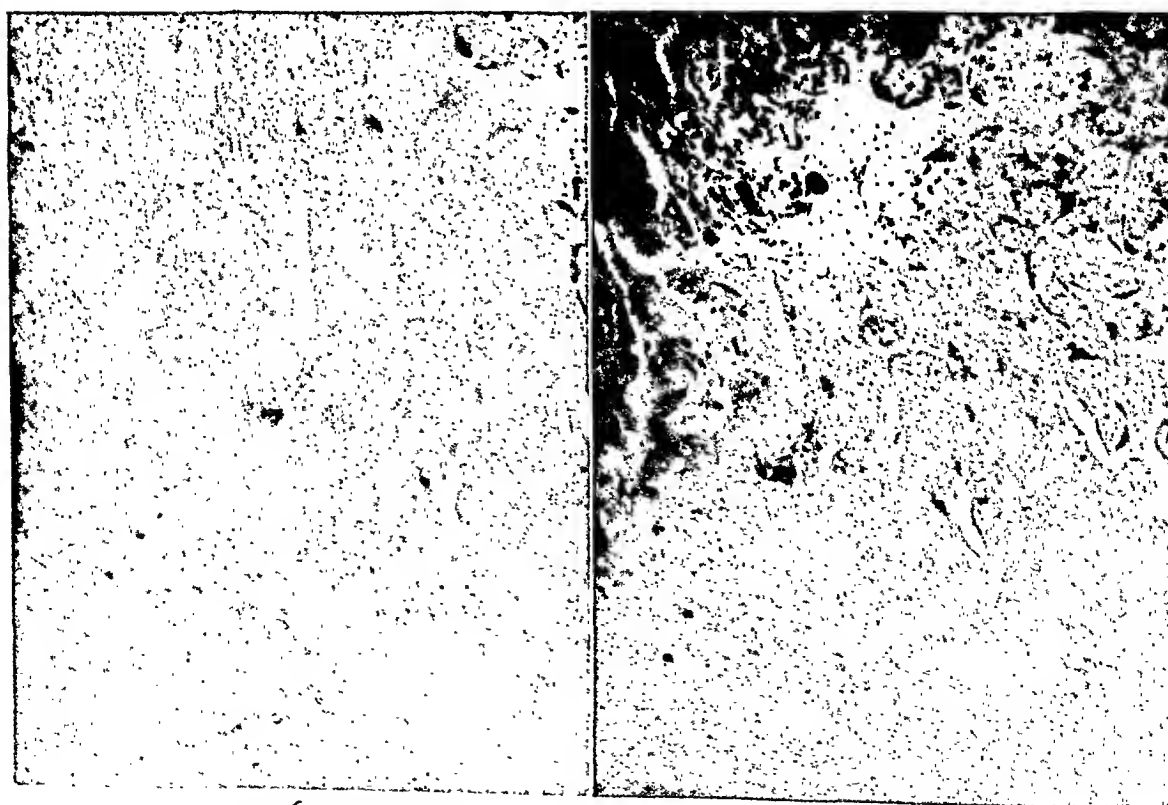


FIG. 3. Microphotograph; hematoxylin and eosin stain; X 63.

Placenta accreta is defined as a pathologic adherence to and/or invasion of the uterine wall by the placenta with absence of the spongiosum layer of the decidua basalis either partially or completely. Three types are recognized in the literature: (1) Placenta accreta in which the placenta is only pathologically adherent; (2) placenta increta in which there is penetration of the uterine wall and (3) placenta



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FIG. 4. Microphotograph; Van Gieson's stain;  $\times 100$ .  
<sup>5</sup>  
FIG. 5. Microphotograph; Van Gieson's stain;  $\times 210$ .



<sup>6</sup>  
FIG. 6. Microphotograph; hematoxylin and eosin stain;  $\times 100$ .  
<sup>7</sup>  
FIG. 7. Microphotograph; hematoxylin and eosin stain;  $\times 100$ .



FIG. 8. Microphotograph; hematoxylin and eosin stain;  $\times 210$ .

percreta in which the uterine wall is invaded to the serosal layer and may actually rupture the uterus. Thus, our case falls into class two or placenta increta.

**Incidence.** Kaltreider, of the University of Maryland, has ably summarized the literature in a recent case report (1945). Incidence of placenta accreta varies according to various authors from 1:1956 to as high as 1:40,000 deliveries. This depends on the strictness with which the term is applied. Many an adherent placenta has been called placenta accreta in past literature but the true picture must occur with greatest rarity. According to Kaltreider, 159 cases appeared in the literature at the time of his publication but he was of the opinion that more had probably been published in inaccessible literature.

**Etiology.** Many theories exist as to the cause of this interesting condition. Some previous trauma to the endometrium seems to be present in all cases. Thus, fibroid tumors, previous dilatation and curettage, endometritis, manual removal of the placenta, previous post partum sepsis, previous cesarean section are all thought to be etiologic factors. Tiemayer suggested a

hormonal theory, chiefly a defect in the corpus luteum. He and King both suggest that improper therapy with endocrines may be a factor.

In our case, manual removal of a placenta had preceded this pregnancy; there had been no hormonal therapy of any kind. Placenta praevia, was another complication in our case existing in the patient's first pregnancy.

**Symptomatology.** The symptoms of complete placenta accreta are silent. There is no bleeding, shock or other systemic symptoms. Therefore, an adherent placenta without vaginal bleeding should always arouse suspicions that this condition exists. The partial placenta accreta, however, shows severe symptoms and hemorrhage may be profuse or moderate. The placenta does not move into the vagina and the patient develops more and more signs of shock due to blood loss which demand immediate treatment by blood replacement.

**Treatment.** In our case, because of instrumentation and succeeding hemorrhage, hysterectomy was carried out with good success. In the previously reported cases, 84 per cent of those with hysterectomy survived but these statistics include cases of ruptured uterus as well as those with instrumental attempts in an era before penicillin. Only 27 per cent of those subjected to manual removal only survived so that this procedure obviously carries the highest mortality. A newer, conservative method has recently been employed by several authors similar to the new method of dealing with the placenta in abdominal pregnancy. In the latter, the cord is tied and the placenta left *in situ* undisturbed to be absorbed later. In the case of the placenta accreta totales, the uterus is packed for twenty-four hours then nothing further is done. The placenta is eventually absorbed or sloughed off as the stimuli from the corpus lutea disappear. Schumann, in Philadelphia, successfully used this method in four cases, Potter in one, Futh in one and Anderson in one; all reported recovery although a stormy convalescence was noted



in each case. In Schumann's series, two cases had normal pregnancies following the procedure. Although penicillin and sulfa drugs have greatly reduced the dangers of infections, still the sections of our case show many areas of acute metritis and many contamination organisms resistant to chemotherapy may, on occasion, invade the sloughing, necrotic placenta. In our opinion, this method should therefore be one of choice only when the desire for succeeding pregnancies is great and the symptoms of infection and potential infection are low.

In partial placenta accreta, or a total accreta case in which trauma has produced bleeding, the conservative method can no longer be a matter of choice. The bleeding is usually very active, so much so that packing will not control it and immediate hysterectomy with supportative and blood replacement therapy is the only method of treatment. Here again prompt recognition of the condition and prompt institution of remedial methods are life-saving and hesitation or indecision invite rapid disaster.

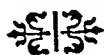
#### SUMMARY AND CONCLUSIONS

A case of placenta increta is herein reported with a review of the literature.

Treatment is discussed with the possibility of conservative measures in total accreta cases as used by Schumann and others. Recommendation is made to reserve this type of treatment for uninfected, total cases without bleeding. In cases with hemorrhage, either due to incomplete placenta accreta or to instrumentation, attention is called to the immediate need for surgical and blood replacement therapy.

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# PRIMARY OVARIAN PREGNANCY OF FOUR MONTHS

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PRIMARY ovarian pregnancy is so rare that in reviewing English and American Literature there are ninety cases reported which are well substantiated. The purpose of presenting this paper is to

merous projections—the fimbriae, the prolongations of the longitudinal foldings of the tube. These are covered with ciliated epithelium. The waving of the cilia moves toward the uterus. An efficient aspiratory



FIG. 1. Ovulation and fertilization. (Taken from a pamphlet describing the various phases of conception and nidation—author unknown.)

FIG. 2. Migration of a fertilized ovum and nidation. (Taken from the same pamphlet as Figure 1.)

add this unusual primary ovarian pregnancy of approximately four months' gestation for statistical studies. In recent years, obstetricians, gynecologists and surgeons have taken pains to report these unusual pregnancies so that today the literature is slowly becoming enriched with the knowledge of these abnormal conditions.

Conception in the obstetrical sense means the union of the male and female elements of procreation. It has variously been termed fecundation, impregnation and fertilization.

How does the ovum reach the tube from the ovary? The ovary lies in a little depression the fossa ovarica, and is covered in part by the mesentery of the tube whose fimbriae are in close proximity. The ampulla of the tube opens outward in nu-

current is produced in the peritoneal fluid in the neighborhood of the end of the tube.

Experimentally in rabbits, Lode saw tiny particles placed in the neighborhood of the tube which were gradually taken in by the fimbriated end. They appeared finally in the vagina. The ovum is caught in this current and led to the tube.

Motile sperm has been found in the vagina as long as thirty-seven hours after coitus and twelve hours in the cervix. In 20 per cent of the cases studied, motile sperms were found in the cervix more than three days after sexual intercourse; thus the sperm can fertilize the ovum even three days after coitus. The sperm reaches the ovum in the tube by means of its own locomotive power. They sometimes overcome obstacles as occur in impregna-

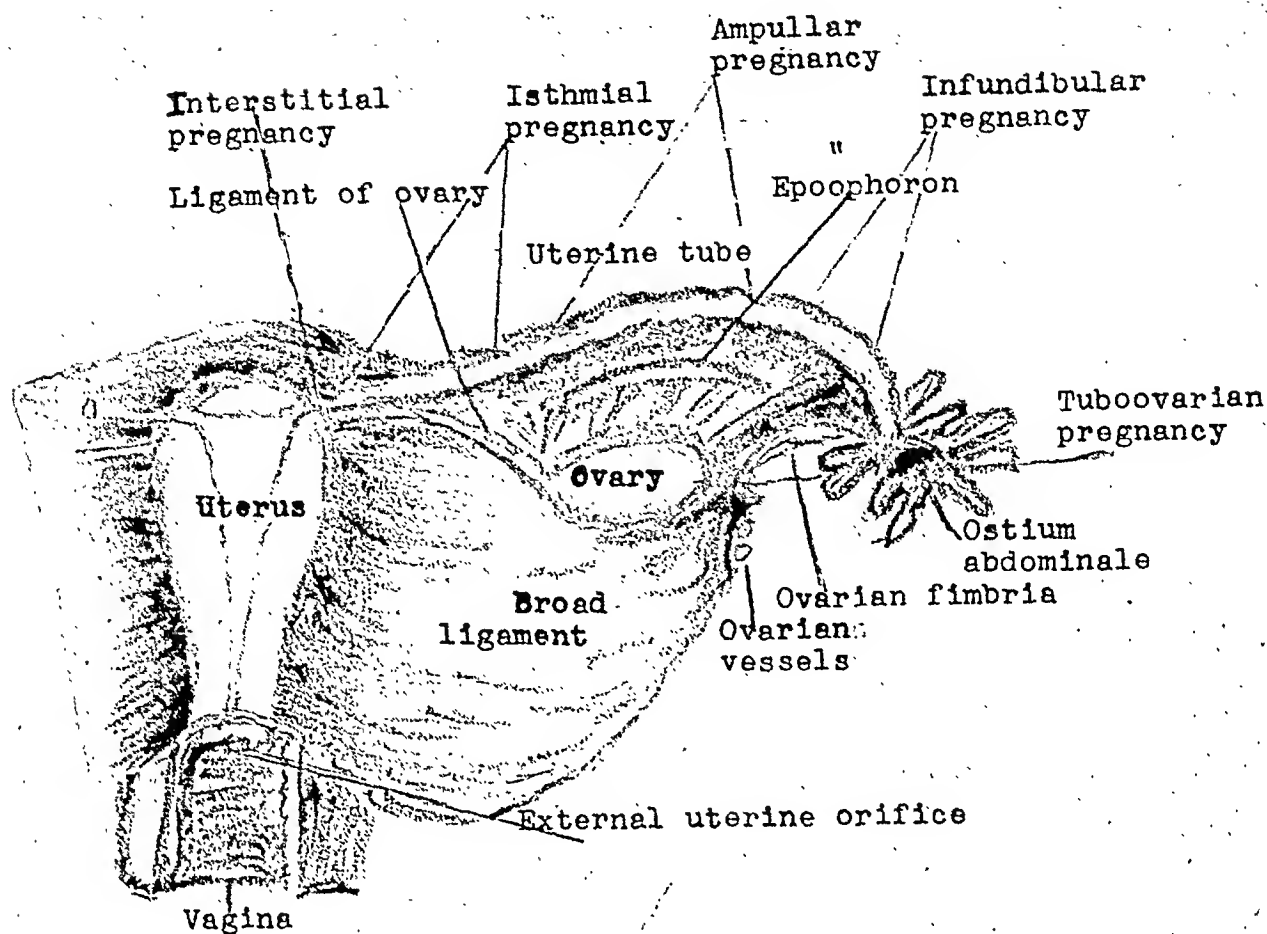


FIG. 3. Posterior view of uterus and right broad ligament. The broad ligament has been spread out and the ovary drawn downward. (From Gray's anatomy.) Pregnancies as described by Crossen and Crossen in "Diseases of Women" are indicated in print.

tion when the semen is deposited on the vulva, as in case of rape and unruptured hymen.

Ectopic gestation or extrauterine pregnancy is the nidation and development of the fertilized ovum in any location outside the uterine cavity.

#### ANATOMICOPHYSIOLOGIC CONSIDERATIONS

The uterine tube, tuba uterina, Fallopian tube or oviduct are synonyms. The uterine tube consists of three coats: serous, muscular and mucous. Each tube is about 10 cm. long and consists of three portions; (1) the isthmus or medial constricted third, (2) the ampulla or intermediate dilated portion which covers over the ovary and (3) the infundibulum with its abdominal ostium, surrounded by fimbriae, is attached to the ovary. The uterine opening is minute and only admits a fine bristle probe; the abdominal opening is somewhat

larger. The internal or mucous coat is continuous with the mucous lining of the uterus and, at the abdominal ostium of the tube, with the peritoneum. It is thrown into longitudinal folds which in the ampulla are much more extensive than in the isthmus.

This form of epithelium is also on the inner surface of the fimbriae, while on the outer surface of these processes the epithelium gradually merges into the mesothelium of the peritoneum. The highly specialized function of the columnar ciliated epithelium of the tube is such that while it permits the secretion of the glands to trickle out of the fimbriated end into the peritoneal cavity, the ovum is gathered by the fimbriae, is brought to the ostium and the cilia propel it toward the cavity of the uterus. The various stages of the process of the fertilized ovum has been studied on mammals. We have no direct knowledge re-

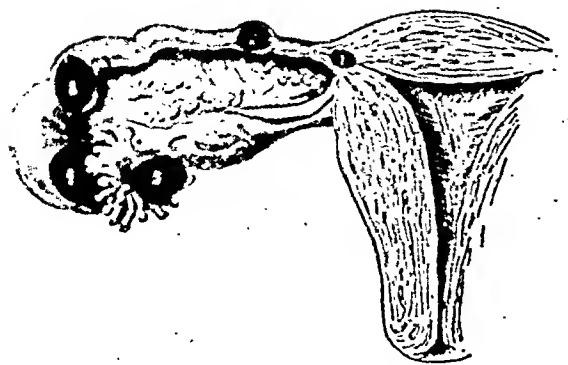


FIG. 4. Extra-uterine pregnancy, as described in Dorland's Medical Dictionary.

garding the fertilization of the human ovum.

It is generally admitted that fertilization takes place in the ampullary part of the uterine tube and the cilia propel it toward the cavity of the uterus assisted by the peristaltic wave of the tube, a journey probably occupying three days. It is stated that unless the egg is fertilized within six hours after ovulation, it becomes impotent or incapable of being fertilized.

#### TYPES

Extrauterine pregnancies are classified as (1) tubal, (2) ovarian and (3) wandering or abdominal pregnancies. Tubal pregnancy is designated according to location: (1) cornual or interstitial, (2) isthmic, (3) ampullar, (4) infundibular and (5) tubo-ovarian pregnancy; "ampullar" (in the outer dilated part of the tube); "isthmial" pregnancy (in the narrow part of the tube near the uterus, and "interstitial" pregnancy (in the interstitial part of the tube). This last type of "extrauterine" pregnancy is within the uterine wall but not in the uterine cavity, unless it breaks into the cavity during the development.

If the pregnancy is found in the peritoneal cavity without any apparent connection with the tubes, uterus or ovary, it is called a wandering or abdominal pregnancy. Such a pregnant mass (fetus and surrounding membranes) may be attached to and receive blood supply from various structures. Tuliolske reported a case in which the placenta was attached to the liver. There is considerable controversy as

to the etiology of abdominal pregnancy and the actual occurrence of primary implantation of the fertilized ovum outside the genital tract. Some believe that "abdominal" implantation is always a "transplant" from an ovarian or tubal position of primary implantation, so that "abdominal pregnancy" can be described as a gestation which is not predominantly intratubal in anatomic position when found. "Primary abdominal pregnancy" can be described as any abdominal pregnancy in which evidences of origin from a primary intrauterine or intratubal position are absent, and wherever the ovary is not definitely involved in the placental site.

Ovarian pregnancy occurs when the ovum is found developing in the ovary. It is the rarest type of extrauterine pregnancies. In this type, cases have been reported in all phases of development, from the earliest stages to that of a mature fetus lodged in the ovary. The literature is incomplete and slightly confusing. However, during the past decade a great deal of interest has been accumulating on the subject so that with successive reports, the true incident will be found. Young and Hawk reported cases of ovarian pregnancies with the incident of 0.7 per cent of all uterine pregnancies in their series of 148 cases. Spiegelberg postulates four requirements for the diagnosis of a true primary ovarian pregnancy: (1) The tube on the affected side must be intact. (2) The fetal sac must occupy the position of the ovary. (3) It must be connected with the uterus by the utero-ovarian ligament. (4) Definite ovarian tissue must be found in the sac wall. Jordan et al. have presented the most complete histologic description of this type of case. They mention the histologic development of such an entity and differentiate between primary and secondary ovarian pregnancy. They speak of intrafollicular and extrafollicular or superficial ovarian pregnancy types.

#### ETIOLOGY

Some observers have found that ectopic gestation occurs in 1:1000. Schuman com-

puted the incident 1:300. More recent observers reduced it to 1:200. It is more predominant with the white race but that of course is due to the difference in size of the population. A normal condition of the oviduct is of primary importance. Abnormality of the tube may interrupt the onward progress of the ovum. *Salpingitis* (gonorrhea) may lead to destruction of the cilia and cause sacculations of the tube itself. The action of the cilia is important to propel the ovum toward the uterine cavity. The peristaltic wave is of secondary importance and not sufficient to carry the ovum along. Inflammation in and around the tube may cause a narrowing of the lumen or the peritubal adhesions caused by the inflammation may lead to a constriction of the tube. The ovum may drop into one of the sacculations or kinks caused by the inflammation; it may be caught there and be unable to make any further progress.

Ectopic gestation occurs more frequently in cities, predominantly after the thirtieth year of life; it occurs usually after a period of long sterility especially in women who have had pelvic disease. Among other causes can be enumerated infantile tubes with imperfect development of the cilia, excessive long tubes causing many convolutions, spasm of the muscular coat or undeveloped muscular coat, abnormal corpus luteum, endometriosis of the tube and ovary and increased invasiveness of the trophoblasts covering the ovum, thus favoring an immediate nidation and puerperal infection.

Explanations have been offered as to why the fertilized ovum does not lodge in the tubes normally. First, the trophoblast is not developed until the fertilized ovum reaches the uterine cavity; secondly, the tubal mucosa is not designed for implantation. Novak believes that the retardation of the progress of the ovum gives time for the development of the trophoblast while the fertilized ovum is still in the tube. A primary or true ovarian pregnancy is one in which the ovum remains in the follicle,

is fertilized there, develops a sac from the contiguous ovarian tissue and continues its growth in the follicle. Secondary ovarian pregnancy is one in which the ovum is fertilized in tissues, tubal or uterine, outside of the ovary, develops its sac from this extra-ovarian tissue and, after developing its sac, becomes detached from its original soil and secondarily attaches itself to the ovary.

The possible mechanism of primary or true ovarian pregnancy is still a matter of speculation: (1) Perioophoritis may cause the ovum to be incarcerated in the follicle, may become impregnated there and grow; (2) a rupture of a centrally placed follicle into a previously vacated surface follicle; (3) retention of Müllerian tissue in the ovary and (4) endometriosis.

To whatever theory we ultimately subscribe we must accept the existence of two constant factors operating in its etiology: (1) that the ovum remains imprisoned within the cavity of the ruptured follicle and (2) that the sperm cell finds its way to this particular ovum.

Most of these ovarian pregnancies terminate by ovarian abortion in the first trimester and are found at laparotomy. They rarely reach full term and are unsuspected by the patient and attendant until labor has supervened which is usually followed by death of the fetus after a period of unproductive labor. Cases have been reported which have gone to full term and a living child has been recovered through a laparotomy.

#### CASE REPORT

M. G., a colored female, para 3, twenty-nine years old, married, very obese, (250 pounds), was admitted to the Morrisania City Hospital from the out-patient department on April 25, 1945, with the presumptive diagnosis of fibroma of the uterus. For three weeks prior to her admission her chief complaint was of lower abdominal pains, pains in the lower part of her back and slight fever. The range of rectal temperature being from 98°C. to slightly above 100°F. For a week prior to her admission she had considerable whitish vaginal discharge but

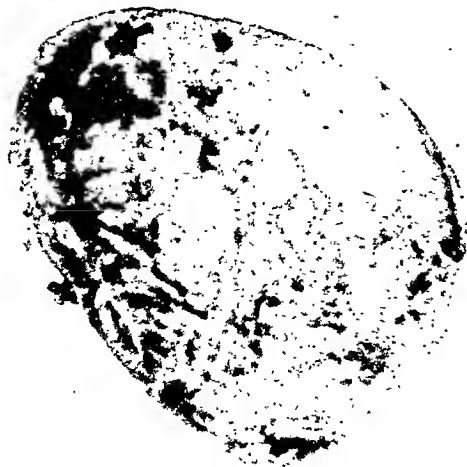


FIG. 5. The pregnancy mass when it was intact.



FIG. 6. Illustration of the fetus when the mass was opened.

no bleeding. There was no history of dysuria nor of a previous operation except for an abscess on the left leg which was incised and healed up very rapidly. She had had no serious illness and her family history was essentially negative. The last menstrual period took place on April 11, 1945.

Physical examination revealed a markedly obese, colored female, not acutely ill. Blood pressure was 162/68; pupils reacted to light and accommodation; breasts were negative for masses. Axillae showed no palpable glands present. The nipples, heart and lungs were normal. The abdomen was very obese. On examination a large globular, smooth, firm mass about the size of a small football could be felt from the symphysis pubes to the left costal border. The mass did not seem to be fixed. It was freely moveable and could easily be pushed to the right of the umbilicus without eliciting either pain or tenderness. Pelvic examination revealed considerable white discharge present. The cervix was normal. The mass felt in the abdomen seemed to have some relation to the uterus. There was considerable tenderness in the left adnexa.

A scar was visible over the left middle third of the tibia. No edema of the ankles was present. She stated that about seven years ago she was treated for women's trouble. Several surgeons examined the patient and made the diagnosis of left ovarian cyst or a large tubo-ovarian abscess with adherent omentum and gut or a pedunculated fibroma. The Kahn test was 1+.

The Wassermann reaction was negative. The examination of the discharge taken from the cervix, urethra and vagina was found to be negative for Neisserian organism. The Aschheim-Zondek test was not done. Three weeks after admission to the hospital (May 17, 1945) the patient was operated upon.

A midline incision was made below the umbilicus, the fascia was incised and the muscle was pulled laterally. When the peritoneum was opened, a large mass, oval in shape and the size of a small football, was found in the abdomen. The mass appeared to be pedunculated and situated well above the brim of the pelvis. A loop of ileum was bound to it, denoting that at some time there must have been an inflammatory process around it. This was more noticeable on the right side of the mass. The left side was bound to parietal peritoneum. The mass was gently peeled by blunt dissection from all adherent structures. A pedicle (which seemed to be the utero-ovarian ligament) was clamped, cut and ligated with No. 2 chromic suture. All bleeding was checked; one penrose drain was introduced into the left pelvic cavity. The left tube was found to be normal. There was no evidence of the left ovary. Closure was completed in layers.

The patient had an uneventful recovery and after eleven days left the hospital cured. In a recent check-up on April 1, 1946, one year later, the patient had no complaints and was doing well.

The pathologic report was as follows: Gross: The mass was about the size of a large grape-

fruit; cut open it contained a fetus partially necrotic and misshapen; the placenta was attached to the wall which was thick, firm and hemorrhagic. Microscopic: Sections through the wall showed almost complete infarction. There were a few cellular elements which were inflammatory and in the necrotic zones; the villi and decidual cells could be distinguished. No ovarian tissue was found.

Diagnosis: Intra-abdominal pregnancy; the origin could not be determined.

### CONCLUSION

From the above mentioned facts one is led to believe that we are dealing with a case of ovarian pregnancy. It is hard to expect all the postulates offered by Spiegelberg, especially when we are dealing with such a large mass; because when the ovary is involved, unless one is dealing with a painstaking pathologist who will make a thorough search of the mass to locate the presence of ovarian tissue, the ovarian tissue may be so displaced and so remotely located that it is well nigh impossible to find it.

We have here 3 of the postulates: (1) the presence of an intact left tube, (2) the absence of the left ovary and (3) the mass seemed to be connected to the uterus through the ovarian uterine ligament. Although the ovarian uterine ligament is not present in the presence of these findings we are dealing with a case of primary ovarian pregnancy. This patient, despite the fact that she was pregnant, menstruated regularly without any interruption and without symptoms. Had the abdomen been x-rayed, the fetal parts would have been seen for the fetus is radiopaque after three months.

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# OVARIAN PREGNANCY

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THE incidence of ovarian pregnancy is still low enough to warrant reporting individual cases.

Russell and Black, in 1940, found only fifty-two cases including the one they re-

nected with the uterus by the utero-ovarian ligament; (3) the walls of the sac must contain graafian follicles and the albuginea of the ovary must pass directly into the tumor wall and (4) the embryo should be *in situ*.

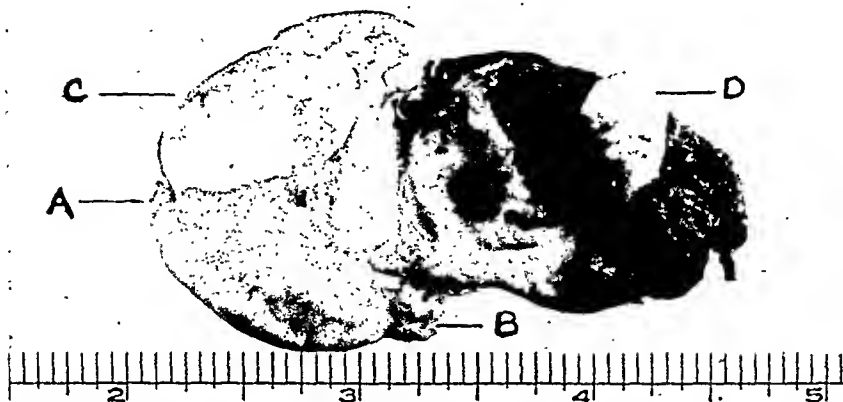


FIG. 1. The tube is seen to the left of the picture with the uterine and fallopian tube at (A) and the fimbriated end at (B). This outer end is *not* adherent to the ovary. The fetal sac in the outer portion of the ovary is clearly seen and the embryo is present at (D). The inner pole of the ovary is seen at (C).

ported which answered the four criteria formulated by Spiegelberg. Stamm, in June, 1946, states that there are eighty-five proven cases reported and adds one of his own. Eckerson found one ovarian pregnancy in the 339 cases of ectopic pregnancy occurring at St. Lukes Hospital, New York, in a forty-year period, an incidence of 0.2 per cent. Young and Hawk report one case in a series of 148 cases of ectopic pregnancies over a period of sixteen years, an incidence of 0.7 per cent. Mann, Meranzet and Leff reported the only case seen at the Mount Sinai Hospital of Philadelphia over a period of twenty-five years.

Spiegelberg, in 1878, outlined the following criteria for true ovarian pregnancy: (1) The tube must be normal and intact and have no organic connection with the gestation sac; (2) the tumor must be con-

## CASE REPORT\*

Mrs. W. H. J., a white female aged thirty-four, was the mother of three children; the youngest was four years of age. Her menstrual history was normal, her last normal period occurring on June 27, 1943. On July 21, 1943, she suffered an attack of severe abdominal pain referred to the epigastrium which required  $\frac{1}{4}$  gr. morphine for relief. The pain soon settled in the lower right quadrant but the patient was up and about her home the following day conducting her household duties. On July 30, 1943, she suffered a similar attack of pain which also required morphine for relief. She was up again the next day but complained of soreness in the lower right quadrant.

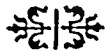
On August 3, 1943, she was referred by her physician to a urologist for a possible renal

\*It is through the courtesy of Dr. John Lucius McGehee, Memphis, Tenn., who sent the specimen to me that I report the above case of ovarian pregnancy.

calculus. The urologist found no abnormality in the urinary tract but during his examination the patient presented symptoms of mild shock and Dr. McGehee was called in consultation.

A diagnosis of ruptured tubal pregnancy was made and the patient was admitted to the hospital. She was given a blood transfusion and operated upon immediately. The abdominal cavity was found to be filled with blood and an ovarian pregnancy was removed.

The gross pathology revealed a specimen which consisted of an ovary measuring 6.5 cm. by 3.5 cm. The distal end of the ovary contained a fetal sac 2 cm. by 3.5 cm. containing an embryo of approximately three and one-half to four weeks' gestation. The stump of the ligament was present at the proximal end of the ovary. The fallopian tube was 3.5 cm. in length and was not connected with the fetal sac.



A FETUS from a missed abortion retained for a long period may undergo dissolution and partial absorption or mummification. Rarely, a lithopedion may form from the deposition of calcium salts within the mass.

From "The Management of Obstetric Difficulties" by Paul Titus (C. V. Mosby Company).

# REPLACEMENT OF UPPER END OF THE FEMUR WITH FIBULAR GRAFT\*

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*Detroit, Michigan*

THIS case is reported because it may be of interest to surgeons who are confronted with the necessity of re- pathologic diagnosis of the primary lesion is not at hand but other features of the case seem to make it worthy of discussion.

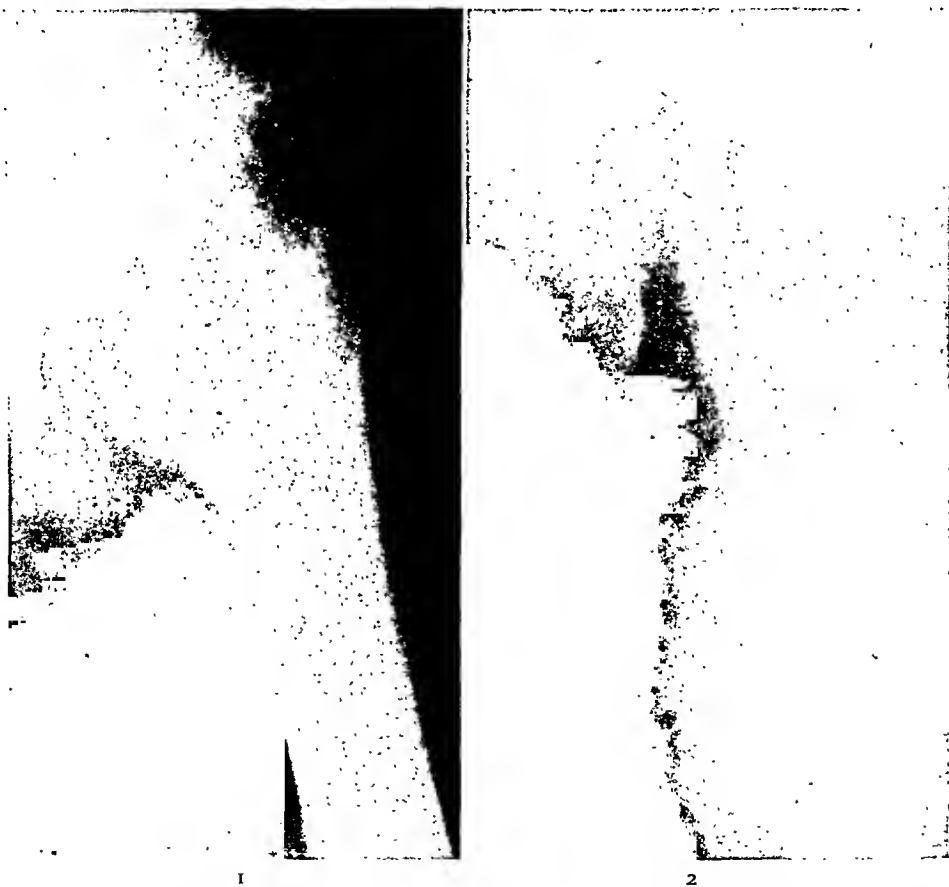


FIG. 1. Roentgenogram showing cystic lesion in upper end of femur with pathologic fracture.

FIG. 2. Roentgenogram taken through plaster cast, showing immediate postoperative position of fibular graft.

moving considerable bone substance in the region of the upper end of the femur. The comparatively long follow-up (twenty-six years) indicates that marked structural disturbance is not inevitably followed by a poor functional result. A clear cut

## CASE REPORT

D. D. G., No. 6071, a white woman of twenty-three years, was admitted to the Henry Ford Hospital on January 6, 1921, with the complaint of severe pain in the left hip. She had had some trouble with this hip since falling

\* From the Department of Surgery, Henry Ford Hospital, Detroit, Mich.



FIG. 3. Fracture of fibular graft, (June, 1921).

FIG. 4. Non-union of fracture of graft, (March, 1922).

on the ice six years before. During the preceding three months, there had been considerable discomfort and for two weeks she had been in bed most of the time. The night before admission, she was walking home from a friend's house when she had sudden excruciating pain in the left hip and sank to the ground. She had to be carried home.

Examination showed marked restriction of motion in the left hip joint because of pain. There was soft tissue swelling in the region of the trochanter. There was atrophy of the left thigh and calf muscles. There were 2 inches of shortening of the left extremity. Roentgen examination revealed a fracture of the femoral neck with rarefaction of the adjacent bone substance. (Fig. 1.) The roentgenologist's impression was that a pathologic fracture was present. No other lesions of the skeleton were observed.

Operation was carried out on January 15, 1921. The following excerpt from the operative record indicates what was done after the hip joint was exposed: "Immediately when the capsule is opened, a dark clot of blood with tumor-like tissue is expelled. The muscles are stripped back from the femur to a point well below the lesser trochanter. The bone is normal up to the level of the lesser trochanter but above this, as it enters the capsule, it is rather

soft. The capsule is turned back and it is found that there is a complete pathologic fracture of the neck of the femur as shown in the x-rays. A piece of the bone is removed and dark, soft mushy tumor with bone spicules in it is curetted out. The entire head of the femur is found to be filled with this substance. The head is pried out of the socket and the ligamentum teres is cut. There is no involvement of the acetabulum or synovial membrane. The tumor extends up into the greater trochanter and down the shaft to the lesser trochanter. First we had the idea of saving the lesser trochanter and sliding it up for the new head of the femur. However, it is thought advisable to remove on a level just below the lesser trochanter. This bone is removed with the curette and rongeur. The surrounding tissues are not involved. The entire capsule, however, is cut away."

This procedure left a bony defect of at least three inches. It was decided to insert a fibular graft. Accordingly, the head and about 10 cm. of the shaft of the left fibula were removed. The distal portion of the graft was thrust into the marrow cavity of the femur and the head was placed in the acetabulum. A plaster spica was applied, maintaining the thigh in abduction. (Fig. 2.)

When the excised tumor was first examined by a pathologist, a number of giant cells and



FIG. 5. Absorption of shaft of fibular graft and fracture of bone peg.

spindle cells were observed. The diagnosis of giant cell sarcoma was entertained for a time but the gross appearance of the tumor and the subsequent clinical course make the diagnosis of benign giant cell tumor more tenable. The case is indexed as the latter in the Bone Sarcoma Registry of the American College of Surgeons (Registry No. 39).

When the cast was changed on February 11th, it was found that the wound had healed *per primam*. There was a left foot-drop, undoubtedly the result of injury to the peroneal nerve during the removal of the fibular graft. On March 28th, the second cast was removed and manipulation and massage were begun. A month later, the patient was allowed to bear weight cautiously on the extremity and was discharged.

After being home a month, she was walking upstairs and felt something snap in her leg. Roentgenograms showed a fracture of the graft. (Fig. 3.) A cast was applied to be followed in August by an ambulatory splint. There was some attempt at callus formation at the site of the fracture, but in March, 1922, it was evident that bony union could not be expected. (Fig. 4.) Accordingly, the site of the fracture was explored and an attempt to fix the fragments with a beef bone peg was carried out by Dr. Charles Peabody. Subsequent x-rays showed persistence



FIG. 6. Appearance of pseudoarthrosis of hip joint twenty-six years after primary operation.

of the non-union and a fracture of the bone peg. (Fig. 5.)

In December, 1922, the peroneal nerve was explored. The traumatized segment of nerve was removed and neurorrhaphy was performed. This was followed by a return of sensation to the affected areas and little or no change in the muscular action.

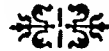
In July, 1924, there was remarkably good function of the hip. The patient walked without a cane. The thigh could be flexed through an arc of 90 degrees. Progress examinations were carried out in 1926, 1929, 1937 and 1947.

The present status of the patient is summarized in the following note by Dr. C. L. Mitchell who examined her on March 12, 1947: "The patient is extremely well pleased with the result she has obtained. She is normally active and had had no discomfort in the left lower extremity for over twenty-five years. Recently she has noticed some grating on motion of the left hip but this has not been accompanied by pain. On examination, we find the patient to be moderately obese. There is two inches of shortening of the left lower extremity. The left foot is held in equinus and she is unable actively to dorsiflex the foot and great toe. Movement of the knee joint is normal. The range of motion of the hip joint is almost normal. Some

crepitus is noted. A slight amount of telescoping is possible. She walks with an elevation of the sole and heel of the left foot but with remarkably little limp. X-rays (Fig. 6) show a rounding of the upper end of the femoral shaft. A good portion of the fibular graft has become incorporated into the upper femoral shaft and there is a pseudo-arthritis between the rounded end of the graft and the acetabulum. The original fibular head has become fused at the acetabulum and a portion of the beef bone graft can still be visualized at the false joint."

#### SUMMARY AND COMMENT

Excision of the upper end of the femur for what was probably a giant cell tumor was carried out twenty-six years ago. The utilization of a fibular graft resulted in a technical failure because of fracture and absorption of the graft. Nevertheless, a satisfactory functional result was obtained. Modern treatment of such a lesion would probably consist of thorough curettage and packing with bone chips.



A WOUND which involves the hip-joint from any aspect is likely to be devastating. Large vessels and nerves, more particularly the femoral vessels and the sciatic nerve, often are implicated and, in addition, the femur and the pelvic bones may be shattered.

From "Surgery of Modern Warfare" by Hamilton Bailey (The Williams and Wilkins Company).

# BONE CYST

## REGENERATION OF BONE FOLLOWING SUBPERIOSTEAL RESECTION

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LIEUT. COMDR. FRANK X. SANSONE  
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AND

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**A**N interesting case of a cyst of the fibula is herein reported together with interesting x-ray films showing preoperative and postoperative status and the result four months after surgical excision.

patient stated that on the night of admission, he tripped and fell down a flight of stairs at his home bumping his left leg against several steps on the landing. He attempted to get up and walk but noted pain in his left leg which seemed to "give way." He stated that he had



FIG. 1. Bone cyst of fibula, showing transverse fracture through mid-portion.  
FIG. 2. Postoperative x-ray showing excision of bone cyst.

### CASE REPORT

A. P. G., eighteen years of age, of Italian parentage, was admitted to the hospital on October 28, 1945, complaining of pain and swelling over the lateral aspect of the proximal third of the left tibial and fibular regions. The

had a similar episode of injury to his left leg two years previously, for which he was bedridden for two days, but that he had been asymptomatic up to the present injury.

His past medical history disclosed that he had had the usual childhood diseases and a



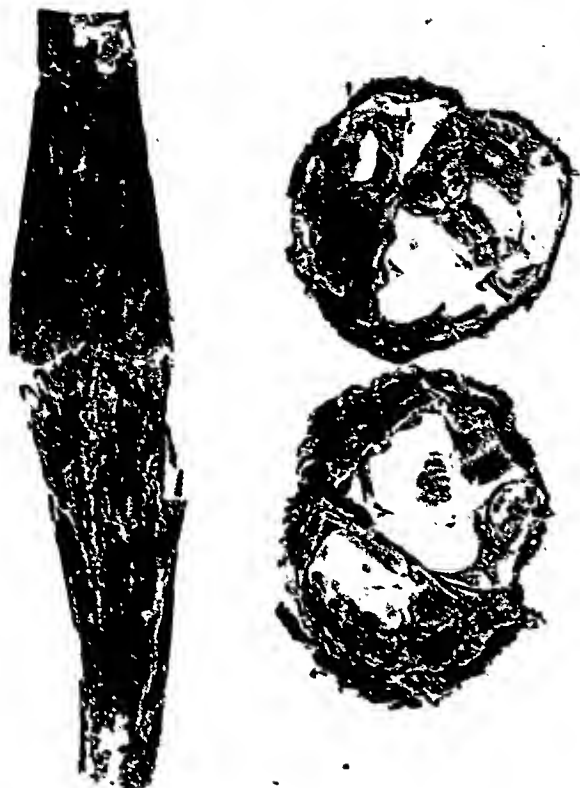


FIG. 3. External view of specimen as removed.  
FIG. 4. View of specimen as removed, bisected at fracture site.



FIG. 5. X-ray taken four months postoperatively, showing regeneration of fibular bone.

questionable fracture of the left scapula four years previous; he also fractured a phalanx of the right little finger eighteen months previous. His family history revealed that his mother and father were both living and well as were three siblings. A systemic review was essentially negative.

A physical examination revealed that his temperature was 98.6°F.; pulse, 76; respiration, 18 and blood pressure, 130/84. The patient was a well developed, well nourished, white Italian male complaining of pain in the left leg. His head, eyes, ears, nose and mouth were all normal. The heart had a normal rate and rhythm with no murmurs. His lungs were clear to percussion and auscultation. The abdomen was normal. There was a lesion 1 cm. in diameter on the dorsum of the penis which was moist and had a serous crust covering. Skeletal examination was normal except for the left leg. There was moderate swelling and tenderness on the lateral aspect of the proximal third of the fibula. There was no bone tenderness over the tibial crest or medial side. There was no limitation of motion of either ankle or knee.

X-ray examination of the left leg revealed a

long, elliptical enlargement of the proximal third of the fibula. The periosteum was broken bilaterally at its central portion which was believed to represent an incomplete fracture at this site. The change had the appearance of a large bone cyst. (Fig. 1.) X-ray examination of all the other long bones of the body failed to reveal any evidence of bone or joint abnormality.

The laboratory studies showed: Red blood cells, 4,650,000; hemoglobin, 15.5 Gm.; white blood cells, 8,900; differential: 59 per cent segmented polys; 2 per cent eosinophiles; 39 per cent lymphocytes with no non-segmented forms, basophiles or monocytes. The sedimentation rate was 5 mm. per hour while the urine examination for Bence-Jones protein was negative. The blood calcium was 11 mg. per 100 cc., blood phosphorus, 4.7 mg. per 100 cc., blood alkaline phosphatase, 4.1 Bodansky units. Four repeated blood Kahn tests were negative.

*Course and treatment.* The penile lesion healed spontaneously without evidence of venereal infection. The patient was operated upon on November 9, 1945. Under pentothal anesthesia and with an Esmarch tourniquet placed at the mid-thigh a 20 cm. incision was

made lengthwise over the lateral aspect of the left fibula. The muscle masses were separated along fascial planes and the tumor was exposed. The periosteum was stripped from the normal looking bone and the bone was parted with a Gigli saw about 1 cm. proximal to and 1 cm. distal to the pathologic appearing bone. The entire specimen, measuring 18 cm. in length, was then dissected free from the surrounding muscles and removed *en bloc*. The large cystic area, measuring 3 cm. in diameter, in the central portion had a paper-thin cortex and contained clear, greenish-colored, thick, fluid material. There was a transverse fracture through the mid-portion of the large cyst. A culture was taken of the cystic fluid and was reported as positive for *Staphylococcus albus*, mannitol fermenting.

The wound was closed in layers with No. 0 chromic catgut and No. 0 nylon to the skin.

The pathologic report on the specimen was as follows: Macroscopically, the specimen consisted of two masses of bone measuring 9 by 2 by 3 cm., having a wedge-shaped contour and a cystic enlargement of the one end with a thin, outer envelope of cortex. Microscopically, the section showed bone trabeculae with many osteoblasts, much fibrosis and many cystic spaces containing free blood. The diagnosis was bone cyst.

The patient was given penicillin, 30,000 units every three hours, intramuscularly for eight

days following the operation and ran an afebrile course. All sutures were removed on the eleventh postoperative day and the wound appeared well healed and clean; he was ambulatory with minimal symptoms.

One month postoperatively, the patient disclosed a small area of redness and swelling in the lower part of the incision which appeared to be a small hematoma. He was given penicillin and hot packs and a few days later two small draining sinuses appeared from which a culture was attained and was reported as non-hemolytic *Staphylococcus albus*. The patient was kept on penicillin and hot packs until January 27, 1946, when the wound was found to be dry. He then was sent on convalescent leave and, after being dry for eight weeks, he was discharged for duty.

X-rays were taken immediately postoperatively and four months postoperatively, the latter of which showed considerable regeneration of the fibula at the site of operative excision of the bone cyst. No union appeared to be established between the short proximal end and the longer distal end of the fibula. This area of bone regeneration presented several round or oval areas of diminished density which gave this new bone a cystic type of appearance. There was nothing to suggest any malignant change in this area. The mineral content of the proximal and distal fibular fragments continued to be good.



# HEREDOFAMILIAL CLEFT FOOT DEFORMITY\*

## (LOBSTER-CLAW FOOT OR SPLIT FOOT)

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CLEFT foot, sometimes known as "lobster-claw foot" or "split foot," is a rare congenital deformity which has a definite tendency toward hereditary transmission. There are many variations of the deformity, and an exact or uniform description of it cannot be given, but the following general statements may be made: The usual deformity is one in which a cleft occurs at the second or third digit and extends a variable distance up the forefoot, perhaps involving even the tarsus, and is associated with a defect or absence of bones in proximity to the cleft. The portions to either side of the cleft are molded into a somewhat conical form usually terminating in distorted joints and giving an appearance not unlike that of a lobster claw.

Grand and Dolan, in 1936, reviewed the extant literature on cleft foot, reported three cases of their own and believed that all four extremities show the deformity, that the hands are never defective in the absence of the deformity of the foot nor is one foot ever deformed alone. The variations in the degree of the defect are many and may involve from one to four toes occasionally including the tarsus. The digits most commonly affected are those adjacent to the cleft. The first and fifth toes in the majority of cases escape. It is an invariable rule that the proximal bone is never absent when a corresponding distal one is present. Of the metacarpal bones which remain those bearing terminal phalanges are usually considerably thickened while those which have no phalanges show hypoplasia.

In our review of the literature through 1945, and in study of our patients, we have

found nothing in conflict with the statements of Grand and Dolan. The deformities of the hand which accompany cleft foot are extremely variable; they include hands with webbed fingers, long thumbs, no thumbs, crooked thumbs, no fingernails, cleft fingernails, small fingernails and missing fingers.

The etiology of cleft foot and deformities of the hand has been made the subject of study by many geneticists. Recorded in the literature are many instances in which cleft foot anomalies have been traced through several generations. The cleft foot anomaly may be explained as a mendelian dominant character in which the distribution and ratio of the affected and unaffected persons is in accord with a single gene interpretation. The hereditary character is assumed to be completely dominant over the normal condition. More males than females are affected but there is not sufficient evidence to warrant consideration of the character as a sex linked, sex influenced or sex limited trait.

Before an attempt is made to treat these cleft foot anomalies for correction of deformity and to improve function it is necessary to have roentgenograms made in at least two planes in order to determine the exact bony structure present. The mere suturing of soft tissues after excision of the cleft may result in failure. In the feet proper, weight-bearing is essential and to obtain this osteotomy or excision of bone usually is required for permanent results. Care in preservation of the blood supply to the remaining digits is necessary for in these conditions the blood supply to the digits often is anomalous. The postoper-

\* An operation devised for correction of deformity.

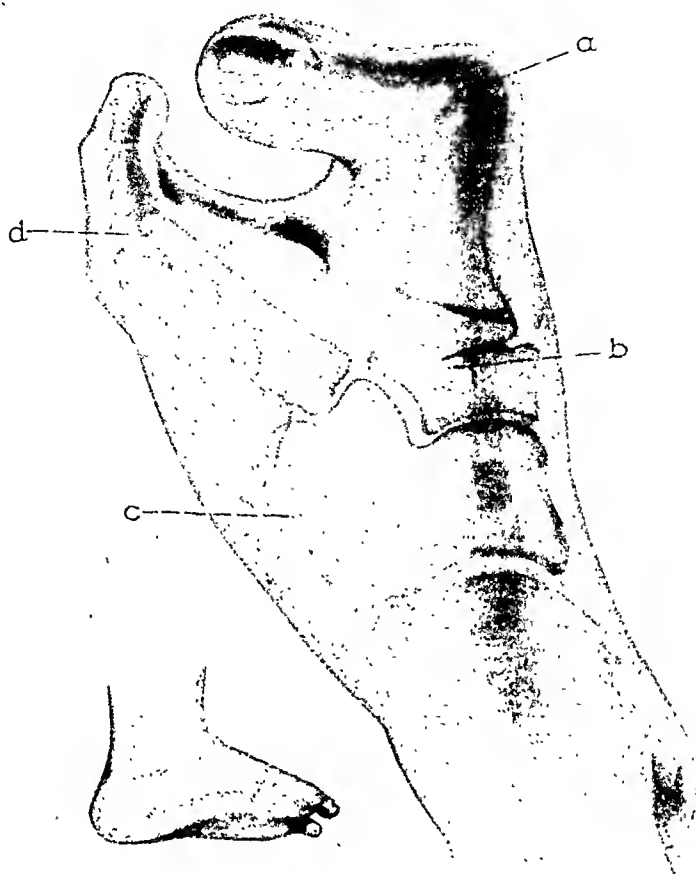


FIG. 1. Left foot, showing: *a*, marked hallux valgus and flexion deformity with bunion over the left great toe; *b*, congenital fusion of the first metatarsal bone with the internal cuneiform bone; *c*, congenital fusion of the cuboid, middle and external cuneiform and navicular bones; *d*, distal articulation of the fourth and fifth metatarsal bones with the middle phalanx of the fifth toe. This drawing shows the actual fusion found at operation.

ative dressings must be carefully applied to allow for swelling. The circulation of the digits should be observed frequently after operation and, on the first evidence of impaired circulation, the dressings should be loosened. The first indications of impaired circulation usually are pain and swelling followed by cyanosis, with cold, clammy, sweaty digits. Elevation of the foot postoperatively will aid in keeping swelling to a minimum. The retentive dressing, plaster of paris casts or splints which maintain the corrected position resulting from surgery must be kept on until the bony parts have become firmly united. The use of specially built shoes postoperatively often is required. In some cases in which the de-

formity is not severe, specially built shoes may be all that is required.

The following case illustrates the cleft foot deformity and its surgical correction.

#### CASE REPORT

A white boy, fifteen years old, was admitted to the Mayo Clinic on June 20, 1946. He had been born with a congenital, bilateral lobster foot deformity in which there was a cleft of the forefoot between the first and fourth metatarsal bones with congenital absence of intervening structures. There was also a congenital web between the third and fourth fingers of the left hand. When the patient was six years of age, the clefts of the forefeet had been partially closed by a simple plastic procedure, performed elsewhere, without any bony reconstruction.

**a****b**

FIG. 2. *a*, Preoperative lateral roentgenograms; *b*, postoperative view of the same foot. The rudimentary joints appearing in these roentgenograms do not show the extent of fusion found at operation.

The boy had been able to walk well and had suffered no pain in the feet until he was fourteen years of age. At this time, he had begun to experience some pain from a "bunion" over the medial aspect of the head of the first metatarsal bone of the left foot. Accordingly, in the spring of 1945, a "bunionectomy" was performed elsewhere. After the operation marked hallux valgus deformity developed on the left with a painful bunion. The deformity of the great toe forced the patient to walk on the lateral aspect of the foot holding the foot in some degree of inversion. The marked hallux valgus deformity of the left foot, with its accompanying painful bunion and fixed inversion of the foot on walking, occasioned the patient's visit to the clinic.

Physical examination revealed congenital absence of the second and third metatarsal bones and the second, third and fourth toes in each foot with a cleft in the skin between the first and fourth metatarsal bones. Old operative scars at the base of the cleft indicated where the proximal aspect of the clefts had been closed previously. Hallux valgus was not present on the right and the foot exhibited no eversion or inversion on weight-bearing. Marked hallux valgus, with a bunion over the medial aspect of the head of the first metatarsal bone, was present on the left. (Fig. 1.) The nature of the hallux valgus deformity was such as to cause dorsal deviation of the first metatarsal bone and inversion of the foot upon walking. Slight varus of the forefoot also was present. Scars were present between the third and fourth fingers of the left hand as a result of

operative procedures carried out elsewhere to separate a congenital web between these two fingers. Function was normal in the fingers except for slight limitation of extrusion of the third finger. The remainder of the general physical examination yielded negative results.

Roentgenograms of the feet (Fig. 2*a*) revealed a congenital absence of the second and third metatarsal bones and phalanges of the second, third and fourth digits bilaterally. Congenital fusion of the navicular bone with the cuboid, middle and external cuneiform bones and the internal cuneiform bone with the first metatarsal bone was seen bilaterally. Rudimentary joints could be seen in the roentgenograms outlining the joints about the cuneiform bones but on examination they were found to be fused. On the left, marked hallux valgus with medial and partial plantar dislocation of the proximal phalanx was seen. Results of roentgenograms of the thorax were negative. Routine examinations of the blood and urine revealed nothing abnormal and a serologic examination gave negative results.

On July 2, 1946, osteotomy was carried out on the fourth and fifth metatarsal bones. About  $\frac{3}{4}$  inch (1.9 cm.) of the fourth metatarsal bone was excised; this permitted the deformed lateral portion of the foot and fifth toe to be brought mesially and somewhat dorsally. About three-fourths of the proximal phalanx of the great toe was resected and heavy scar tissue was removed to allow swinging of the great toe from its 80 degree lateral deformity into proper alignment forward. A dimple on the ball of the foot and a scar from the previous operative incision were

excised to facilitate approximation of the lateral and medial portions of the foot. The patient preferred not to have the right foot operated upon at that time.

On the ninth postoperative day, a cast extending from the toes to the knee was applied and the patient was permitted to be up on crutches and to return home. On August 8, 1946, five weeks postoperatively, the patient returned for re-examination. The cast was removed and the wounds were found to be healed. There was a much improved weight-bearing surface and a more normal appearing foot than existed prior to operation. (Fig. 2b.)

The patient returned to the clinic on July 7,

1947, for operation on the right foot, for he was very much pleased with the benefit derived from the operation on the left foot. Hence, a similar operation was performed on the right foot, after which a cast was applied. The cast was removed at the end of three weeks, at which time the wounds had healed, with primary intention. The stitches were removed and the patient returned home on July 30, 1947, with instructions to wear a cast, which we applied for three months.

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*Announcement:* The American Urological Association offers an annual award of \$1,000 (first prize of \$500, second prize \$300 and third prize \$200) for essays on the result of some clinical or laboratory research in urology. Competition shall be limited to urologists who have been in such specific practice for not more than five years and to residents in urology in recognized hospitals.

For full particulars write the secretary, Dr. Thomas D. Moore, 899 Madison Avenue, Memphis, Tennessee. Essays must be in his hands before March 1, 1948.

# A DANGER SIGNAL IN TRAUMATIC ANTERIOR DISLOCATION OF THE HIP

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A REVIEW of the literature reveals no mention of dilatation of superficial veins occurring after anterior hip dislocations.

## CASE REPORT

A thirty-seven year old white soldier was admitted to an overseas Army General Hospital on September 2, 1945, in severe shock. The weapons carrier which he had been driving had crashed into a tree causing the following injuries: (1) Fracture, comminuted, lower half left femur and fracture, compound, comminuted, upper half of left tibia involving the knee joint, severe; (2) dislocation, simple, anterior type, hip, right, severe and (3) multiple lacerations, superficial.

The patient was in considerable shock and was somewhat irrational. Examination revealed markedly dilated veins measuring 1 to 2 cm. in diameter over the inner aspects of the right thigh and leg along the saphenous distribution. There was slight cyanosis of the foot. No pulsations were present in the posterior tibial artery or dorsalis pedis artery. The right lower extremity was held in abduction, external rotation and slight flexion at the hip. The knee was flexed and the lateral aspect of the right foot was resting on the floor. There was a marked prominence in the right femoral trigone region. The femoral pulse could be felt immediately above this area. The swelling was obviously bony in character and rotation of the hip caused motion of this mass which was identified as the head of the femur.

There was a gaping wound over the lateral aspect of the left upper leg. The left knee joint was greatly swollen. There was deformity in the region of the left knee joint. Swelling was moderate in the upper leg region.

Immediate treatment consisted of splinting of the lower extremities in Thomas leg splints. The wounds were temporarily dressed and shock treatment instituted for the next four

hours. Three bottles of plasma and two pints of matched citrated blood were given intravenously. Blood pressure reached a level of 130/80. Medication consisted of one  $\frac{1}{2}$  gr. dose of morphine on admission, and one  $\frac{1}{4}$  gr. dose of morphine along with  $\frac{1}{150}$  of atropine subcutaneously before operation, penicillin 40,000 units intramuscularly, and tetanus toxoid 1 cc. subcutaneously. Oxygen was administered before and during the operation.

Operation was started five hours after injury and was performed under satisfactory sodium pentothal anesthesia supplemented by oxygen. Kirschner wires were inserted into the lower left femur and into the upper and lower portions of the left tibia for subsequent reduction and suspension traction. The left leg wounds were débrided and dressed with sulfanilamide powder locally and vaseline gauze. Attention was then directed to the right hip. The pelvis was supported manually against the table by two assistants. The operator gently flexed the right thigh with moderate manual traction. The hip was slowly rotated internally with adduction. The head was felt to snap but careful examination revealed that the head had dislocated posteriorly. The extremity had assumed a position of flexion, internal rotation and adduction. A maneuver consisting of rotation, flexion, and moderate traction allowed satisfactory reduction of the head into the acetabulum. Just prior to the latter manipulation, the patient's respirations became accelerated with increasing hyperpnœa. Cyanosis developed and breathing gradually ceased. This episode took place in an interval of approximately three minutes. Last minute measures consisted of artificial respiration and injection of adrenalin into the jugular vein. During the operation, intravenous whole blood had been administered. Auscultation immediately following the change in the patient's condition and just prior to death revealed rapid, weak heart sounds and harsh breath sounds.



## COMMENT

It was the consensus of the staff members, who were present during the operation, that death was due to the dislodgment of a thrombus in the right femoral vein and pulmonary embolism. This occurred presumably when the pressure of the femoral head against the great blood vessels was relieved during the reductions of the head into the acetabulum. The chain of events leading to the sudden change in respirations, particularly at the instant of hip reduction, seems to indicate that the locus of thrombus formation had occurred in the right femoral region during the five-hour period prior to reduction. There had been marked venous engorgement of the long saphenous system prior to reduction. The possibility of fat embolism was considered. The pulse and respirations were rapid and blood pressure was normal about five minutes prior to death. Sudden exodus occurred simultaneously with manipulative reduction of the hip. It was a little early for fat embolism to have occurred although early cases have been reported.

Anatomic diagnosis following autopsy was as follows: (1) Fracture, compound, comminuted, upper half of tibia, left, into knee joint; (2) fracture, simple, comminuted, lower half of femur, left, into knee joint; (3) multiple lacerations, superficial; (4) dislocation, anterior type, traumatic,

hip, right, post-reduction; (5) embolism pulmonary, probable site of origin from femoral vein, right.

*Autopsy Procedure on Right Hip Joint.* A Smith-Petersen approach was made into the right hip joint. The head had been satisfactorily reduced in the acetabulum. The femoral head was dislocated by manipulation. Direct vision indicated that the head of the femur caused pressure against the posterior aspect of the great vessels in the femoral region. Section of these vessels, however, revealed no evidence of thrombus formation. The head was then carried through the same maneuver that had been attempted just prior to death and a posterior subluxation occurred. When the method of manipulation was reversed, a stable reduction was accomplished. The joint capsule was intact but there was evidence of relaxation.

*Comment.* If reduction of the hip could have been accomplished sooner than it was, death might not have occurred. The delay necessitated by shock treatment and the taking of x-rays in all probability contributed to thrombus formation in the femoral trigone region.

Venous engorgement of the saphenous system should serve as a sharp warning for the need of early reduction of anterior hip dislocations due to trauma if thrombosis and embolism are to be avoided.



# SIMULTANEOUS OCCURRENCE OF MULTIPLE PRIMARY CARCINOMAS WITHIN THE ABDOMINAL CAVITY\*

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THE following case of adenocarcinoma of the sigmoid colon and a papillary cyst adenocarcinoma of the ovary is reported because of the rarity of the occurrence of two separate and unrelated carcinomas in the same patient. The case is also of interest because of the sudden onset of the few symptoms in a patient apparently in good health until the present illness.

## CASE REPORT

Mrs. E. C., a white female, aged fifty-five, was admitted to the hospital on August 25, 1946, with the chief complaint of abdominal distention and obstipation. The patient apparently had been in good health until July 25, 1946, at which time she suddenly became constipated. Three days later she noted increased abdominal growling, became alarmed and consulted her family physician. The prescribed therapy failed to control the symptoms which increased in severity and were accompanied by abdominal distention and constant cramp-like pains. The odor of food nauseated the patient and she began to vomit frequently. On August 5th, she sought the advice of a second physician and three days later, after numerous enemas and laxatives, the bowels moved for the first time in two weeks. During the next few days there was slight bowel action, the stool being soft and small in amount. On August 12th, the patient again reported constipation. Two days later she was referred to a roentgenologist for a gastrointestinal examination during the first part of which she drank a glass of barium suspension and afterward returned home. That night she became acutely ill and failed to complete the roentgen-ray examination. The earlier symptoms of abdominal distention and cramp-like pains recurred and on August 24th a third physician

advised immediate hospitalization.† The previous medical history of the patient was irrelevant.

On admission the patient appeared acutely ill. The skin was pale and dry; the oral temperature was 101°F. The significant physical findings, with the exception of small grade I internal hemorrhoids, were limited to the abdomen which was markedly distended and tympanitic throughout, with tenderness to palpation in the left lower quadrant. Sigmoidoscopic examination, extending as high as 24 cm., revealed no abnormalities.

The laboratory data on admission August 25, 1946, were as follows: Examination of the blood revealed a red cell count of 4,890,000, a hemoglobin content of 15.8 Gm. per 100 cc., and a white cell count of 6,400 with a differential count of polymorphonuclears 69 per cent, lymphocytes 28 per cent, and monocytes 3 per cent. Urinalysis of a voided specimen showed a 2 plus turbidity, 3 plus acetone and many pus cells. Blood chemistry studies showed the non-protein nitrogen to be 76.5 mg. per cent, plasma chlorides 498 mg. per cent and the plasma protein 5.55 mg. per cent. The blood type was AB. Roentgen-ray findings from a flat plate of the abdomen made at the time of admission revealed barium outlining the large bowel. No barium could be visualized in the rectum, suggesting that there was an obstruction in the large bowel near the rectosigmoid junction.

Fluoroscopic examination on August 28th showed the large bowel still distended and outlined by the barium. At this time a left transverse colostomy and cecostomy was done to wash out the barium and relieve the obstruction. The immediate postoperative condition of the patient was good and the symptoms of obstruction rapidly disappeared.

Thirty-seven days later, on October 4th, a

† Case referred through the courtesy of A. J. Huesman, M.D.

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Miles type of combined abdominoperineal resection and a radical Wertheim hysterectomy were done. A bowel segment 38 cm. in length was removed incorporating the sigmoid colon with the adjacent mesenteric tissue, the rectum, a section of anal skin and fatty tissue. No lymph node enlargement was noted at this time. There were no metastases to the liver. The patient reacted well postoperatively. The colostomies were subsequently closed proximal to the lesion and the patient was discharged from the hospital January 16, 1947.

The pathologist's report was as follows: A tumor mass on the right ovary consisted of a multilocular cyst with a glistening translucent surface, measuring 12 cm. in diameter, containing turbid mucinous fluid. The lining was smooth and membranous except for clusters of soft, light tan adenomatous cysts, the largest measuring 4 cm. in diameter, implanted on its surface. In another area of the tumor mass there was a cluster of small cysts containing serous and pseudomucinous fluid. Microscopically, the tumor tissue was papillary adenocarcinoma, with numerous acini of irregular size, some of which contained mucoid material. The nuclei were hyperchromatic. There was some invasion of the underlying stroma by the epithelial cells. Areas of necrosis occurred throughout the tumor. The remaining portion of the right ovary had a thickened tunica and measured 4 cm. in length. On section, the normal tissue had been replaced by a mass of soft, pultaceous, light tan iridescent material. The left ovary macroscopically was not remarkable but on section there was a large area of degenerating material mixed with a fibrous stroma containing numerous clefts formed by giant cells and distended phagocytes filled with a brown pigment. Beneath the serosa near the fundus of the uterus was a small myomatous tumor 2 cm. in diameter consisting of benign intertwining smooth muscle fibers. The endometrium was soft, pinkish red and atrophic except for a small polyp 4 mm. in its greatest extent; microscopically, the endometrium was not remarkable.

In the sigmoid colon 29 cm. from the anus was a constricting annular tumor 2.5 cm. in

its largest extent. It involved the entire circumference of the mucosal surface except for a narrow section 9 mm. in width. The tumor was a primary adenocarcinoma, grade 3, arising from the mucous membrane and involving all the layers of the intestinal wall except the serosa which grossly did not appear to be invaded. The mucosal portion of the tumor was sharply delimited peripherally from the adjacent normal appearing mucosa. The tumor cells contained moderately anaplastic mitotic figures. There were no discernible lymph nodes in the mesentery segment either at the tumor site or elsewhere along the portion of bowel removed. A small white nodule in the areolar fatty tissue proved on section to be metastatic adenocarcinoma.

**Diagnosis:** A diagnosis was made of (1) papillary cyst adenocarcinoma of the ovary, (2) adenocarcinoma of the sigmoid colon, grade 3 with metastasis and (3) leiomyoma uteri.

**Comment.** While the condition of multiple primary carcinomas is not rare, the simultaneous occurrence of multiple primary carcinomas within the abdominal cavity is quite rare. Within the ten-year period of 1936 to 1946 no instance of this was found in the records of St. Mary's Hospital, Cincinnati, Ohio. At Memorial Hospital,\* New York, there have been 370 cases of multiple primary carcinomas in the past ten years. In some of these the tumors did not occur simultaneously; in no case did two separate and independent lesions develop simultaneously within the abdominal cavity.

#### SUMMARY

A case is reported of the occurrence in the same patient of two simultaneously growing primary carcinomas, the one a papillary cyst adenocarcinoma of the ovary, the other an adenocarcinoma of the sigmoid colon, grade 3, with metastasis, together with a leiomyoma uteri.

\* Personal communication, John L. Pool, M.D.



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# New Instruments

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## HIP NAILING BOARD

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**A**N orthopedic table with a cassette holder is not always available when and where the surgeon wishes to nail a hip. An extra assistant may not be available to hold the leg during the operation. A combination cassette and leg holder placed on any operating table solves these two problems. The reduction is accurately maintained during the operation and the taking of x-rays is facilitated. (Figs. 1 to 4.)

The combination cassette and leg holder replaces the center section of the pad on any operating table. The cassette is inserted from the side opposite the hip to be nailed and the x-ray is operated from the same side. After anesthesia is induced neck fractures are reduced by the Leadbetter method; the foot of the table is dropped and the leg of the patient is locked in internal rotation with the knee flexed at an 80 degree angle. The opposite leg is likewise locked to "fix" the pelvis. A small pillow or pad is placed under each knee to protect the peroneal nerve. Only the operation site need be prepared. A sterile lap sheet is used to cover the patient.

The table is tipped in a Trendelenburg position so that the pull of the body on the inclined plane will produce sufficient traction to maintain proper valgus position of the head of the femur. A 10 to 20 degree angle will suffice for neck fractures while a

30 to 40 degree angle may be required for intertrochanteric types. Neck fractures require maximum internal rotation; trochanteric fractures may reduce better by placing the femur in neutral position or slight external rotation.



FIG. 1. Position of hip nailing board on operating table, showing cassette partially inserted.

After guide wires, nail or pins are inserted lateral x-rays are best taken by unlocking the leg and holding it in a position of abduction, flexion and external rotation. The operator may thus position the leg by unlocking the holder and grasping the knee and ankle through the sterile drapes. This brings the neck parallel to the cassette and the position of the tube need not be changed. If preferred, lateral x-rays may be taken without unlocking the leg by positioning the tube to shoot past the opposite knee with the cassette held in a sterile pillow case obliquely against the hip.



FIG. 2. Preoperative position of patient.

FIG. 3. Trendelenburg position for traction with leg locked in internal rotation.



FIG. 4. Position for taking lateral x-rays of the femoral neck.



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## A NEW INDEX—VOLUMES 1 TO 80

A CHICAGO surgeon relates an experience of some years ago when he was asked to see a patient in a southern Illinois city who had been suffering for five weeks with a serious but baffling illness. The symptoms were those of a progressive intra-abdominal lesion associated with a continued remittent fever. The only localizing symptoms were some enlargement of the area of liver dulness, failure of movement of the right diaphragm and some cloudiness of the lower portion of the right lung just above the diaphragm. It was suggested that the patient might have a subdiaphragmatic abscess, that a diagnostic puncture should be made, and followed by surgical drainage if pus were present.

The surgeon in charge of the case was hesitant; he felt uncertain as to the diagnosis and as to what should be done. He asked if the consultant would remain and help carry out the procedure suggested.

The consultant consented but his peace of mind was little increased as he heard the surgeon call his colleagues on the telephone and say that the visitor had made a diagnosis of subdiaphragmatic abscess and would operate at nine in the morning.

As he thought about the problem the visitor remembered that some five or six years before Nather and Ochsner had described in SURGERY, GYNECOLOGY AND OBSTETRICS a method of approach to collections of pus about the diaphragm that had appealed to him as practical and surgically sound. The local surgeon was certain the paper in question could be found in his library.

The library proved to consist of long open shelves filled from floor to ceiling with books and unbound medical periodicals. These were arranged without any semblance of order. Recent numbers of the *Journal of the American Medical Association* hobnobbed in friendly fashion with ten year old numbers of the *Annals of Surgery* and the *Archives of Internal Medicine*. It was necessary actually to rearrange some eight or nine hundred periodicals,

and then to arrange the individual numbers of SURGERY, GYNECOLOGY AND OBSTETRICS in order. By checking the indices in each June and December number the paper in question was finally found (1923, 37: 665-673) and proved exceedingly helpful.

The operation was carried out on the following morning before a gallery of local medical men. The right twelfth rib was resected and a large caliber needle was inserted through the thickened periosteum and into the space underneath it. As thick grey pus was drawn into the syringe everyone, including the visiting surgeon, gave an audible sigh of relief.

This somewhat intriguing incident carries a moral that the thoughtful reader has already anticipated. Medical periodicals are most useful if they are kept in bound volumes, arranged in order, and *if an index is readily available*. Every busy surgeon has had the experience while working at home late at night, or perhaps in the early hours of the morning, of trying to recall where that paper appeared which he would so much like to review in preparation for a difficult operation, or a clinic, or a presentation to the surgical society. He does not have the *Index Medicus* at hand. It seems an expensive luxury and it is available in the library of the medical school or the hospital, but not at midnight. An index, not of all medical literature, but of the periodicals to which he subscribes would be of very great help to him.

It is such an index that SURGERY, GYNECOLOGY AND OBSTETRICS is preparing for its readers and planning to offer to its subscribers within the next few months—an index of volumes 41 to 80 to supplement the index of volumes 1 to 40 published in 1927. It is hardly necessary to point out its obvious advantages. It is only hoped that the many subscribers and readers of the journal will find the new index a help and convenience in their purposeful reading and study of the many important surgical subjects and problems considered during the twenty years represented by volumes 41 to 80.



